Iron and Steel ENGINEER

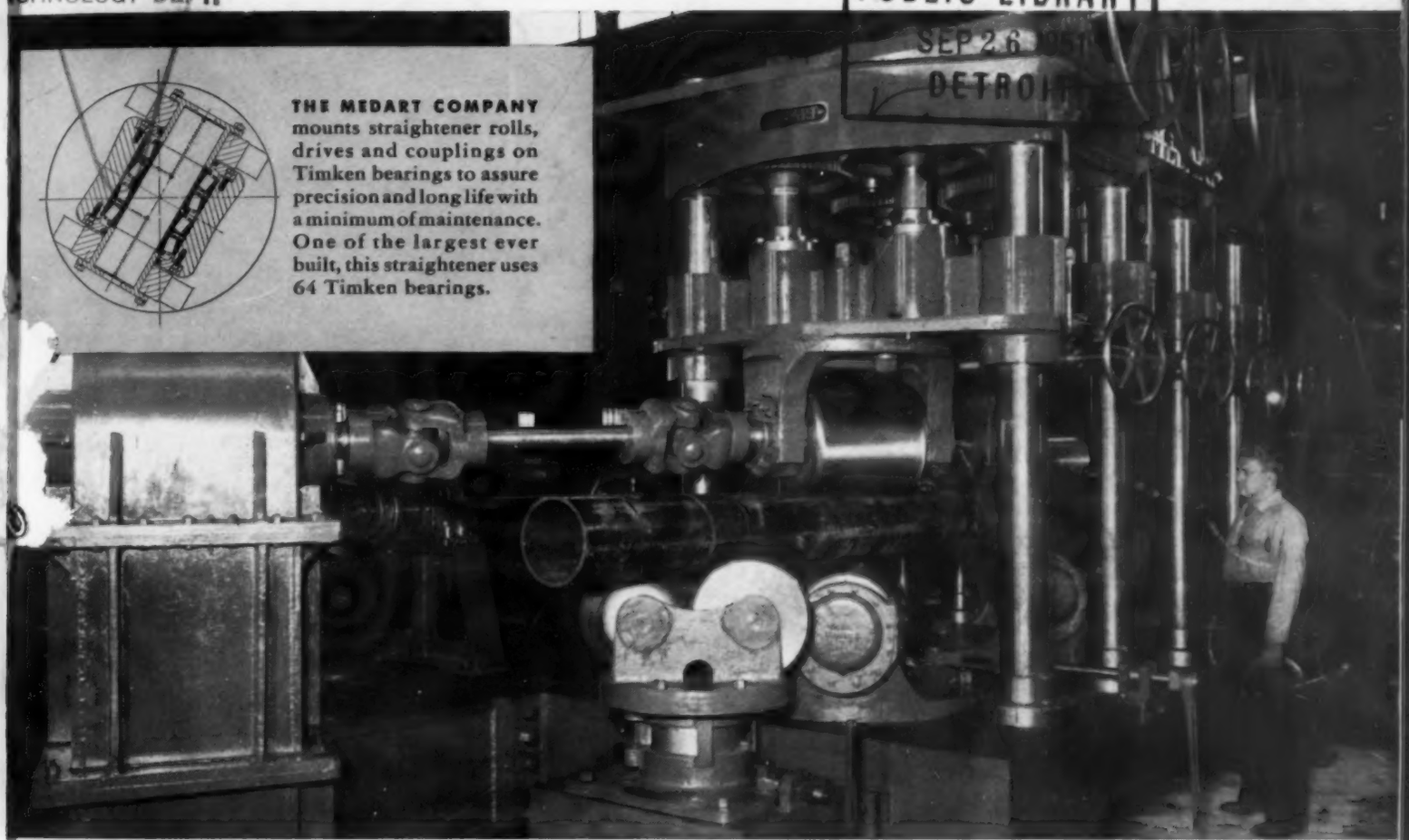
ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

SEPTEMBER, 1951

ECHNOLOGY DEPT.

PUBLIC LIBRARY
SEP 26
DETROIT

TABLE OF CONTENTS, Page 73



THE MEDART COMPANY mounts straightener rolls, drives and couplings on Timken bearings to assure precision and long life with a minimum of maintenance. One of the largest ever built, this straightener uses 64 Timken bearings.

Precision's a pipe for pipe straightener on TIMKEN® bearings

THIS Medart #10 Multicycle Rotary Straightener is one of the largest ever built. It will straighten up to 16" O.D. pipe with less stress—and at high speed! To assure precision straightening and long, trouble-free life, the rolls, drives and couplings are mounted on a total of 64 Timken® bearings.

Timken tapered roller bearings take radial and thrust loads in any combination due to their tapered design. Shafts are held in positive alignment, gears mesh accurately. Line contact between the rollers and races gives Timken bearings extra load-carrying capacity. And Timken bearings permit tighter closures that retain lubricants longer, keep dirt and moisture out.

Timken bearings are first choice throughout industry. Look for the trademark "Timken" on the bearings you use. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario, Cable address: "TIMROSCO".

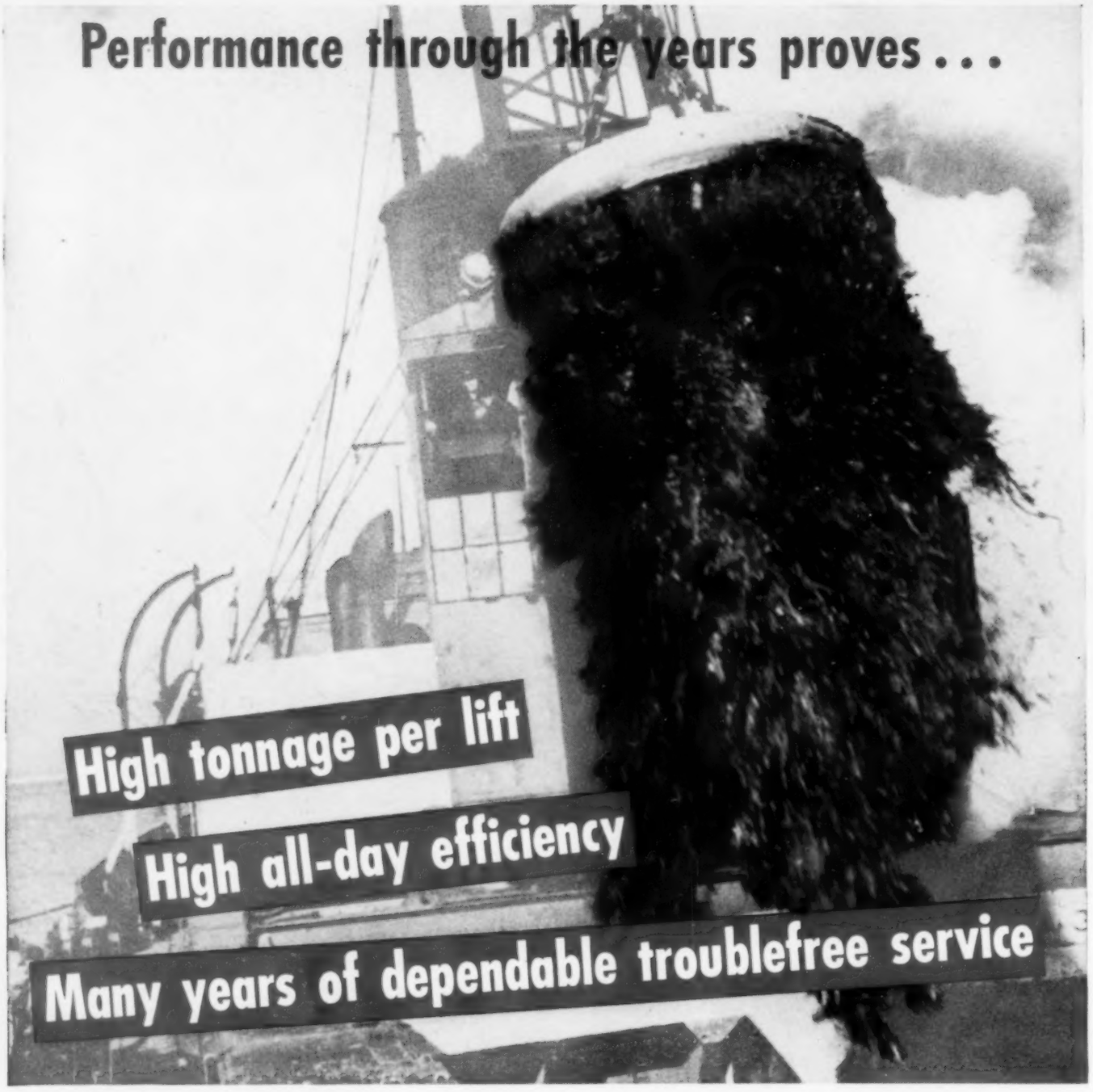
TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ◯ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION →✳←

Performance through the years proves . . .



The records of Cutler-Hammer magnets through almost 50 years of service—in steel mills, scrap yards, and foundries; on railroads, ships, and docks—tell more than words can do why these magnets have earned such an enviable reputation for rugged, dependable day-after-day performance with minimum out of service time.

The secret of any magnet's lifting power lies in its coil. The coil of every C-H Supermagnet, wound under tension, vacuum impregnated with a special compound, baked to form a solid mass, is sheathed in a welded sheet steel housing that makes coil moisture troubles a thing of the past. Dynamo steel body for greater lift, tough alloy pole shoes that resist wear and increase strength, double sealed water-tight terminal box, and a yoke design that keeps chains separate and prevents twisting for added chain life . . . these are features that have made Cutler-Hammer modern Supermagnets the choice wherever iron and steel are handled.

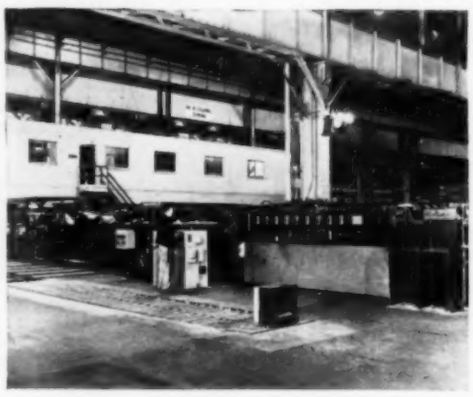
If you are a Cutler-Hammer magnet user you know these facts. If not, we suggest the only completely satisfactory way you can learn them—specify Cutler-Hammer magnets on your next order and compare the results. CUTLER-HAMMER, Inc., 1257 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER-HAMMER
SUPERMAGNETS
C-H

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 28, No. 9

84" SHEAR LINE

The Aetna-Standard 84" Shear Line for cold-reduced product at the Gary Sheet and Tin Mill, plant of U. S. Steel Company, features several innovations. In this view, from the entry end, you can see the mandrel type pay-off reel for 72,000 lb. coils; a special loading ramp to prevent coil damage; pinch roll unit; looping pits; 16" heavy duty side trimmer and Hallden Flying Shear.



The delivery end features a magnetic prime piler. The Side Trimming and Shearing Line features a Scrap Baller forming a ball 36" O.D. x 60" wide. The line speed is 90' to 450' per minute, processing sheets from 30" to 200" in length, widths from 18" to 74".

aetna-standard

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Plants in Warren, Ohio • Ellwood City, Pennsylvania

ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England—Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.

Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.

M. Castellvi, Inc., New York, N. Y.—Mexico, Central and South America.

Societe de Constructions de Montbard, Paris, France—France, Belgium, Holland, Luxembourg, Switzerland.

Demag Aktiengesellschaft, Duisburg, Germany—Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.

Compagnia Italiana Forme Acciaio, Milano, Italy—Italy.

Aetna-Japan Company, Ltd., Tokyo, Japan—Japan.

Hale & Kellgren, Inc., Akron, Ohio—Representative for the Rubber Industry.

Designers and Builders to the Ferrous, Non-Ferrous, Leather and Rubber Industries

Designers and Builders of Complete Steel Plants

General Offices and Works of the Mesta Machine Company

MESTA

Mesta is equipped to build the unusual. Unequalled plant facilities . . . the most modern machinery, including heavy duty lathes, grinders, boring mills, planers, draw-cut shapers, and gear hobbers . . . skilled workmen with long service records . . . a large and capable engineering department are all responsible for Mesta's ability to produce precision, heavy duty equipment.

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

• • • • The world knows of America's fabulous steel production. It knows that our capacity to fashion the weapons of war is a fearsome thing.

And we know that steel has contributed more than any other industry to our daily lives. Everything we use . . . from toothbrushes to neckties . . . starts with steel.

The development of better refractories for every step in steel . . . and tremendous advances in production . . . have helped largely to make possible steel's progress. General Refractories is proud of its part.

Hot Air That Talks Sense

GENERAL REFRACTORIES

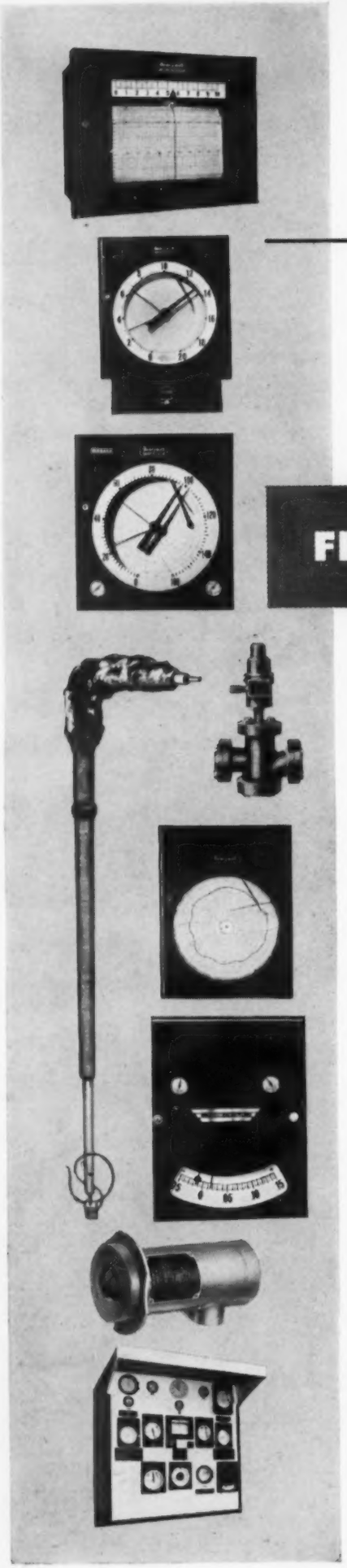
GENERAL REFRACTORIES COMPANY
PHILADELPHIA

General's OLIVE HILL fireclay brick lines this blast furnace. And elsewhere in the plant you'll find General Refractories silica brick, basic brick, plastics, castables and bulk products. There's scarcely a heat application for which General does not supply a refractory.

General's extensive research facilities and modern production methods . . . General's 43 mines, 29 plants, 18 sales offices and 200 distributing agencies . . . are at your service. If you have a refractory problem, depend on the company that offers a complete refractories service.

A Complete Refractories Service

●



Brown Instruments

HELP YOU PRODUCE... MORE EFFICIENTLY... MORE ECONOMICALLY

FROM ORE...TO IRON...TO STEEL

WHEREVER steel is produced . . . wherever it is treated, formed, and fashioned into its innumerable end uses . . . there you will find Brown instruments, control systems and services helping make *better steel*, and *better steel products*, at lower cost.

Brown instruments have advanced through the years . . . with the industry's leaders . . . always in step with the needs of tomorrow, meeting the exact specifications of each new technique.

Brown serves the metals industry by making available:

COMPLETE INSTRUMENTATION—The world's largest selection of unit control systems cover operations ranging from mining ore to automatically controlling the finish of a delicate manufactured product. Every encountered variable: temperature—pressure—pH—conductivity—flow—speed—motion—thickness—smoke—haze—dust—combustion—gas analysis, etc., is efficiently indicated, measured, recorded or controlled.

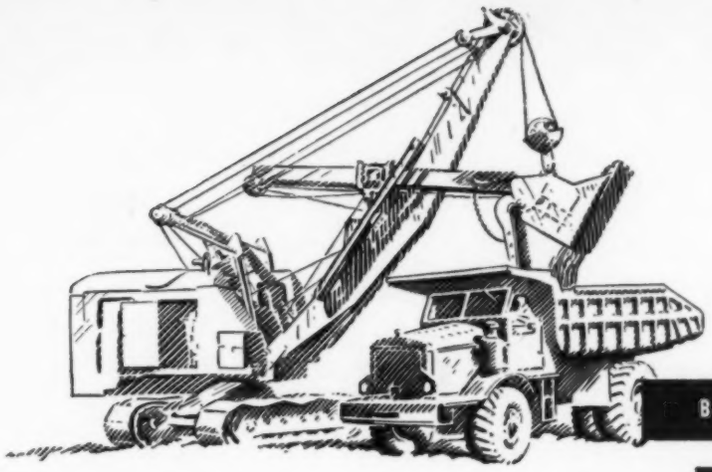
SERVICE AND MAINTENANCE—The world's largest instrument service organization to keep these industries operating at peak efficiency.

TRAINING SCHOOL—trains industry personnel to obtain maximum benefits and continuous life from instruments and control systems.

INDUSTRY SPECIALISTS—located in all major producing areas provide practical, constructive help in industry's problems.

HSM PLAN—makes possible new convenience and savings in the purchase of pyrometer supplies.

COMPREHENSIVE LITERATURE—catalogs, bulletins and specification sheets on products and systems . . . Instrumentation Data Sheets on practical industry applications.



FOR

Beneficiation, flotation, sintering,

kilns, coke ovens, by-product plants,

blast furnaces, electric furnaces,

...TO FINISHED PRODUCTS

open hearths, bessemer converters,

cupolas, soaking pits, reheating furnaces,

forging furnaces, roughing mills and

finishing mills, tinning, galvanizing,

pickling, cleaning, and annealing,

TO

plant services and laboratories.

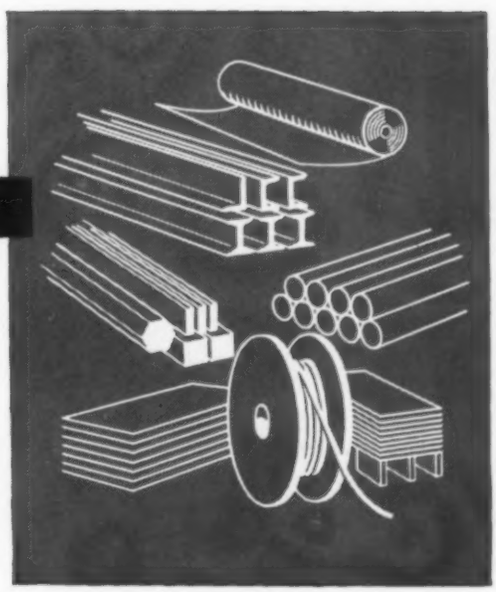
Measure, record and control

(pneumatically or electrically),

pressure, temperature, speed, motion,

thickness, pH, flow, gas analysis,

smoke, haze and dust, combustion.

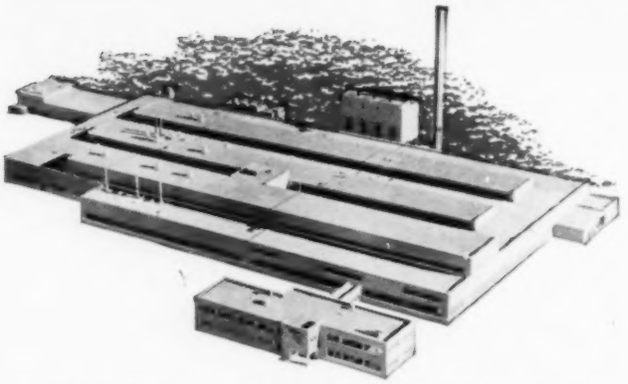


Information on any specific instrumentation problem will be furnished upon request. Write, or call in our local engineering representative . . . he is as near as your phone!

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4464 Wayne Ave., Phila. 44, Pa.

MINNEAPOLIS
Honeywell

Brown Instruments



N-B-M Meadville . . . where the welcome mat is out. We're proud of this plant—its equipment and the skilled people who work in it. Proud enough, in fact, to offer a standing invitation to Blast Furnace Superintendents or other steel mill officials to visit us. When can *you* make an inspection trip?

These Bosh Plates take it standing up

Here's where you'll find *vertical* molding of copper castings . . . resulting in cleaner metal throughout.

Another reason why N-B-M Meadville is a name to remember when you specify copper castings. During 75 years of foundry experience, you learn many answers to better methods of production . . . methods that *improve casting quality and soundness.*

At N-B-M Meadville, one of these quality-improving production methods is *vertical molding*—eliminating chaplets. We've found—both by test and on-the-job experience—that vertical molding means uniformly higher quality. Any N-B-M Representative will welcome the chance to describe this unique method to you.

From the molding floor to the shipping room, N-B-M Meadville accomplishes what should be, and is, the main objective of this modern, well-manned plant . . . ***what you specify . . . we ship.***

AMERICAN **Brake Shoe** COMPANY

NATIONAL BEARING DIVISION

4936 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

Continental

Blooming-Slabbing Mills

CASTINGS: Carbon and Alloy Steel; from 20 to 250,000 Pounds.

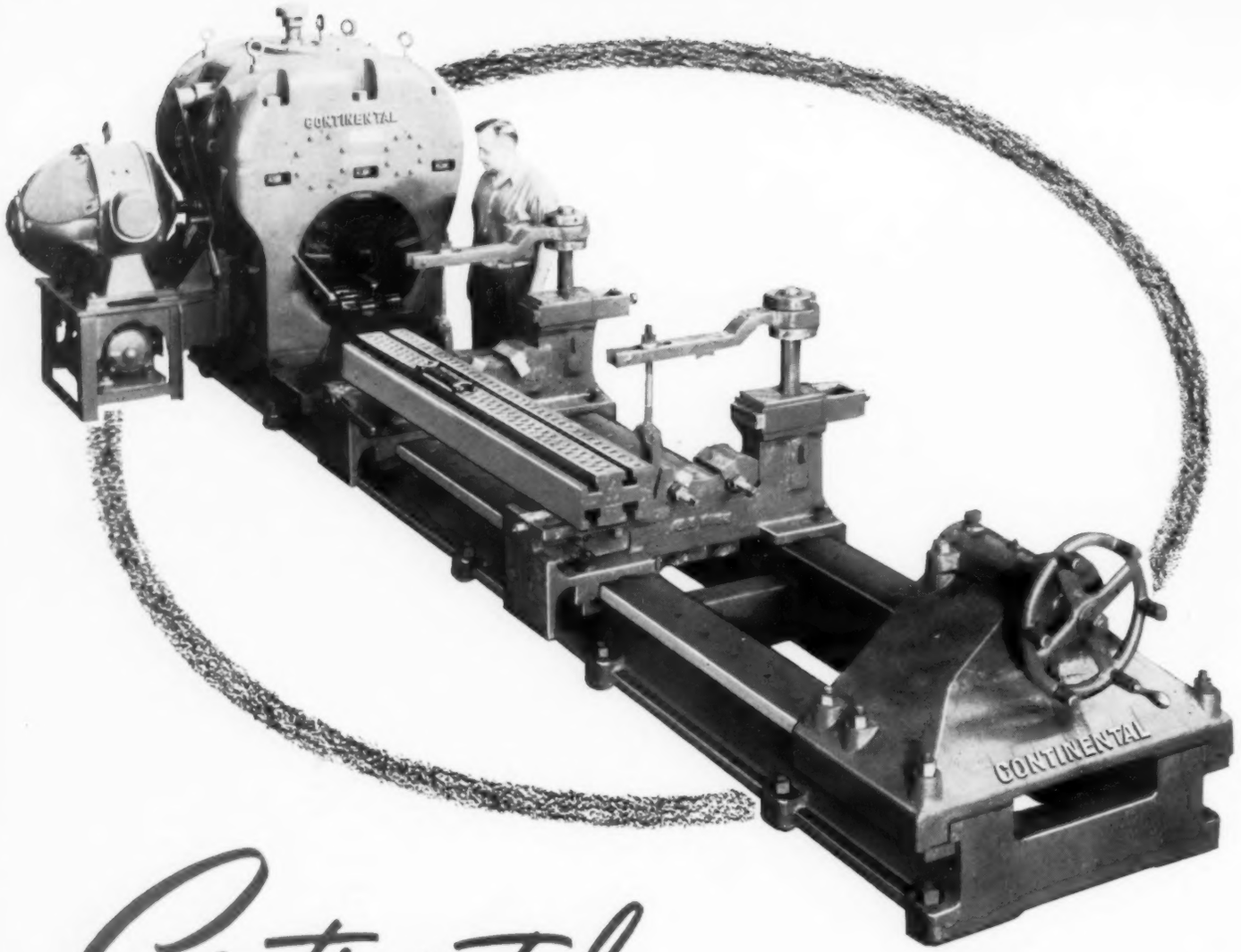
ROLLS: Iron, Alloy Iron and Steel; for All Types of Rolling Mills.

MILLS: Complete Installations of Rolling Mills and Auxiliary Equipment.

CONTINENTAL
Foundry & Machine
Company

CHICAGO ★ PITTSBURGH

Plants at East Chicago, Ind., Wheeling, W. Va., Pittsburgh, Pa.



Continental ROLL LATHES

CASTINGS: Carbon and Alloy Steel; from 20 to 250,000 Pounds.

ROLLS: Iron, Alloy Iron and Steel; for All Types of Rolling Mills.

MILLS: Complete Installations of Rolling Mills and Auxiliary Equipment.

Continental

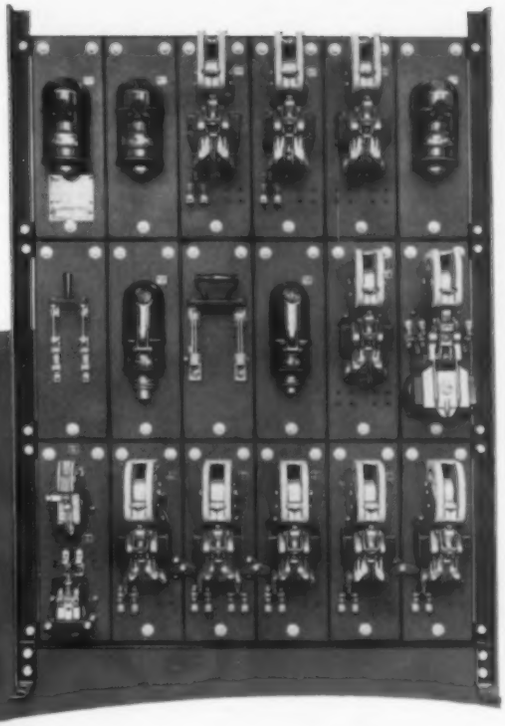
CONTINENTAL
Foundry & Machine Company

CHICAGO ★ PITTSBURGH
Plants at East Chicago, Ind., Wheeling, W. Va., Pittsburgh, Pa.

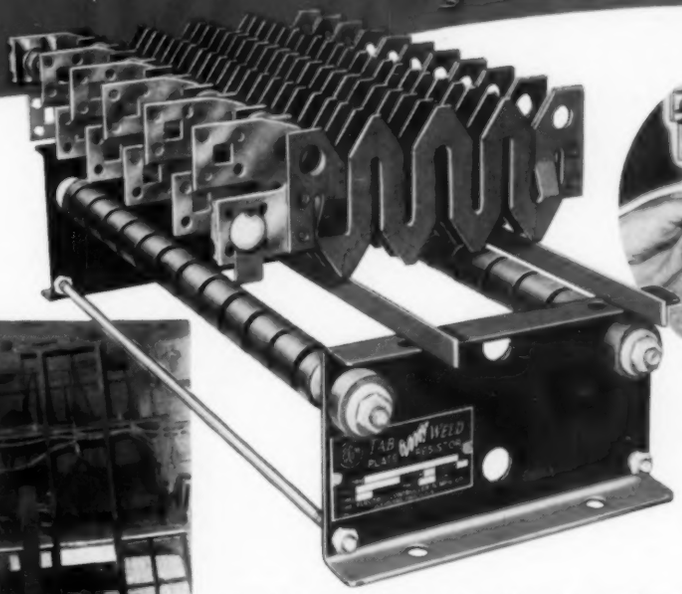
8

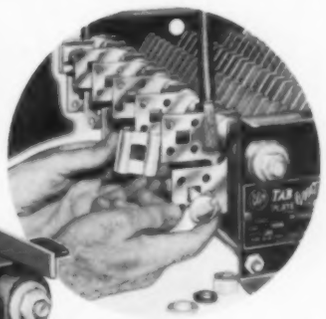
Important Features of **EC&M** *Magnetic Control*

1 Time-Current Acceleration
2 Line-Arc Contactors
3 Wright Hoist Circuit
4 Tab-Weld Resistors
5 Cam Master Switches
6 Safer Electrical Interlocks
7 Bolted, Welded Frame
8 Quick Contact Renewing



Save on upkeep with TAB-WELD PLATE RESISTORS





To shift the external lead-wire, only the terminal-block need be moved. The terminal-blocks are grooved to accommodate several sizes of wire, or flat-bus may be bolted to the terminal-plates.

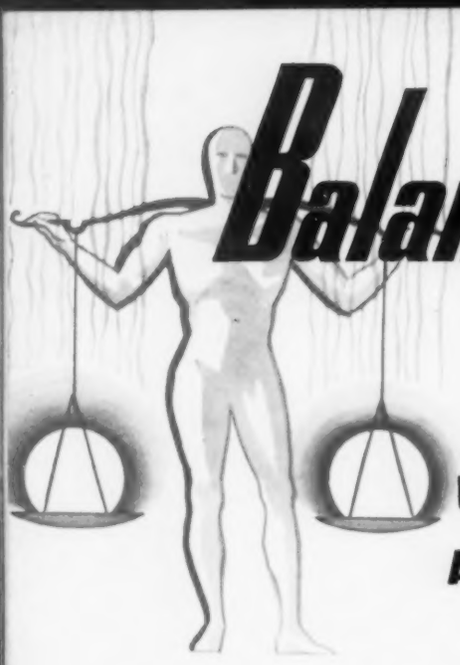
TAB-WELDS SAVE UP TO ⅙ ON UPKEEP

Control purchasers like the plus value in EC&M TAB-WELD Plate Resistors. No burning at grid-eyes or at tap-plates—and, as shown in the circle view, simplified tap-shifting when shifting taps is needed for improved performance.

There's no need to fear that failure to tighten end-clamping nuts will cause damage by burning. Also, there's more time for the maintenance crew to inspect, check, adjust and maintain other units of the drive.

Make your own layouts with Bulletin 942-A TAB-WELD Resistors. They will pay for themselves quickly through reduced upkeep expense.

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO



Balanced Heat Flow IN 'SURFAC CO

VOLUME PRODUCTION AND CLOSELY CONTROLLED ANNEALING, UNHEARD OF IN PAST EMERGENCIES, ARE POSSIBLE FOR TODAY'S DEFENSE AND CIVILIAN REQUIREMENTS.

Four 'Surface' developments, used together in a balanced heat transfer system, *are breaking records for top speed and true quality in annealing.*

'Surface' harnesses heat for the steel industry. Hundreds of 'Surface' annealing covers and bases in America's leading steel mills employ the components shown below to produce thousands of tons of bright-annealed flat rolled steel each hour. They are operating in every important steel mill center from coast to coast.

1 COIL SEPARATOR ● Simple, rugged construction balances convection heating and cooling. Directs rapidly circulated heating and cooling gases to ends of coil laminations. This utilizes solid metal heat transfer, rather than conduction through laminations.

2 HIGH POWERED BASE FAN ● Power input is many times greater than used formerly. Incorporates a unique 'Surface' designed method of sealing annealing atmospheres against differential pressures.

3 CORRUGATED INNER COVER ● Deep corrugations absorb and transfer heat to circulated gases within the inner cover during heating cycle and speed cooling of the charge by reasons of the large area exposed.

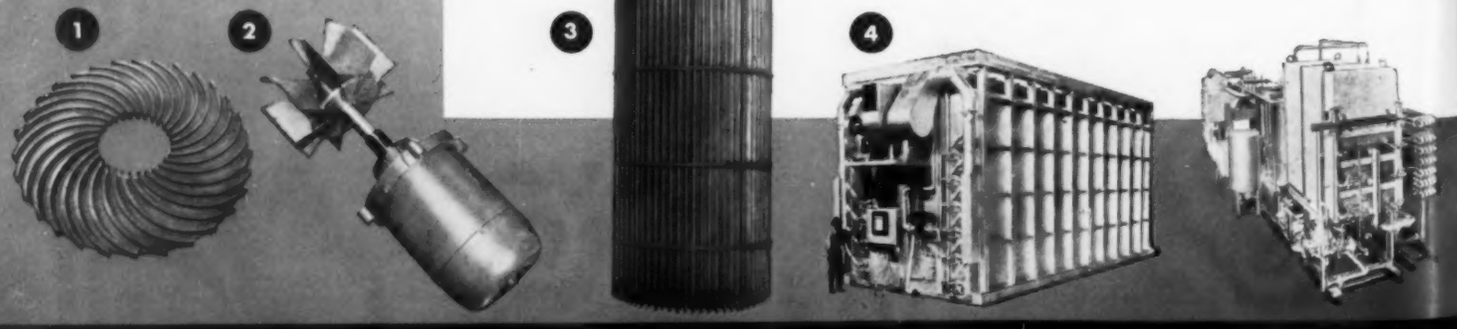
4 RADIANT TUBE HEATING COVER ● Stepped-up, useful heat input of 'Surface' radiant tubes balances the fast heat absorption rate of the new deep-corrugated inner covers and fast heat transfer of base fans and coil separators.

Here's an additional 'Surface' development that assures "Quality Control" of heat treated products.

HNX ANNEALING ATMOSPHERE GENERATOR ● Non-explosive HNX gas provides complete surface protection for steel in 'Surface' cover-type annealing furnaces. HNX is an improved form of widely accepted NX gas.

Shown here is a batte of 'Surface' radiant tube coil annea ing covers of the rectangular doub row type utilizing a protective a trolled atmosphere for bright annea ing rolled steel sheets.

Submit your heating and heat treat problems to 'Surface' engineers for heat-engineered recommendations and latest equipment.



COVERS...RESULTS IN FASTER AND BETTER ANNEALING

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

FOREIGN AFFILIATE COMPANIES

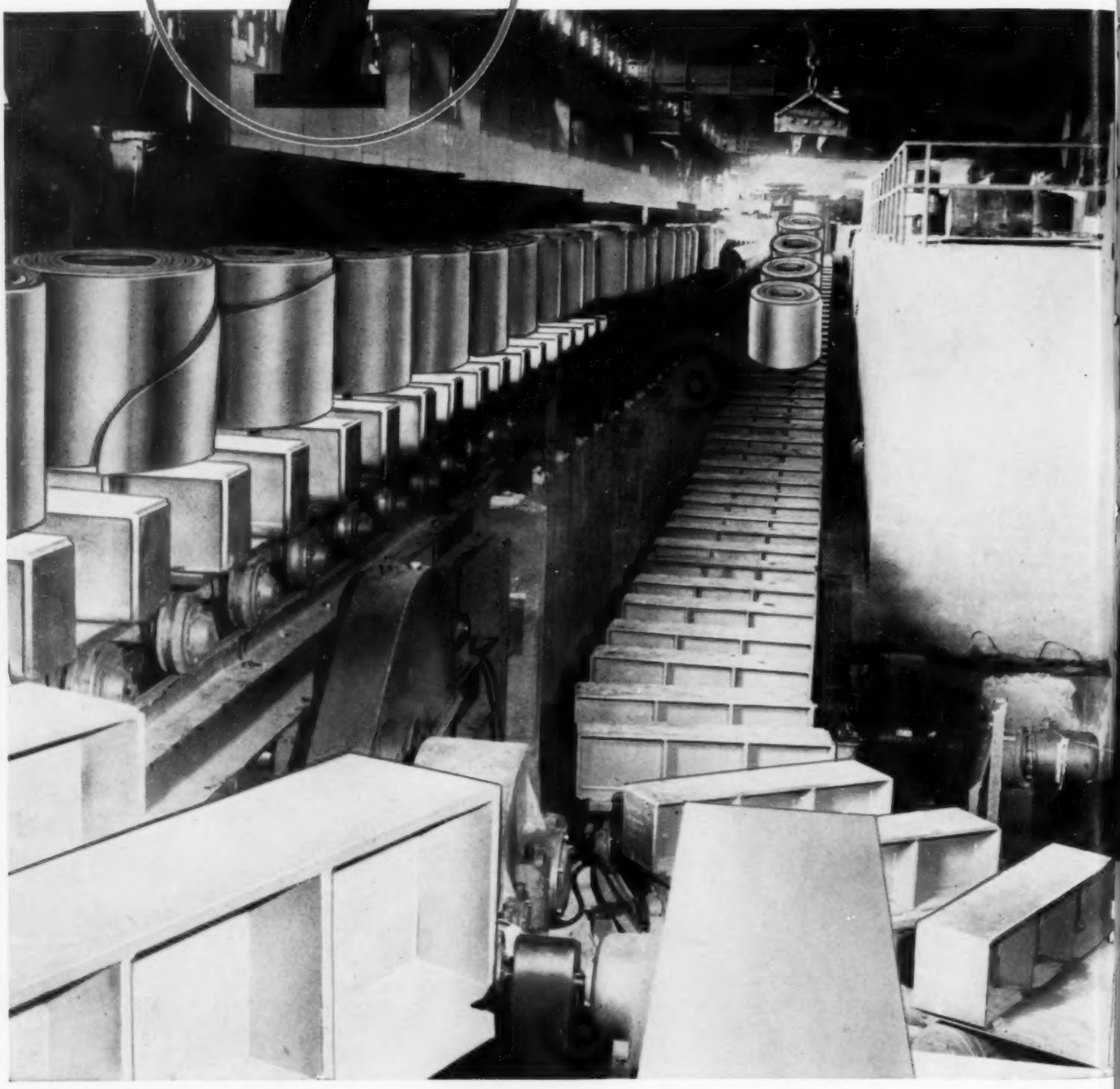
BRITISH FURNACES LIMITED—CHESTERFIELD
STEIN & ATKINSON, LTD.—LONDON

STEIN & ROUBAIX—PARIS, LIEGE AND GENOA
WILL L. SMITH, S.A.—BUENOS AIRES

'Surface' SERVES THE STEEL INDUSTRY

One-Way Fired Soaking Pits • Billet Reheating Furnaces • Slab Heating Furnaces • Continuous Type, Controlled Atmosphere Strip Annealing and Normalizing Furnaces • Controlled Atmosphere Annealing Covers for Wire and Rod • Controlled Atmosphere Annealing Covers for Coil and Sheets • Continuous Furnaces for Heat Treatment of Steel Plate • Controlled Atmosphere Furnaces for Carbon Correction in High Alloy Rod and Bar Stock • Continuous Type Bright Annealing and Normalizing Furnaces • Prepared Gas Atmosphere Generating Equipment • Pit Type Convection Furnaces for Rod Annealing • Stress Relief Furnaces • Wire Patenting Furnaces

7 WAYS TO

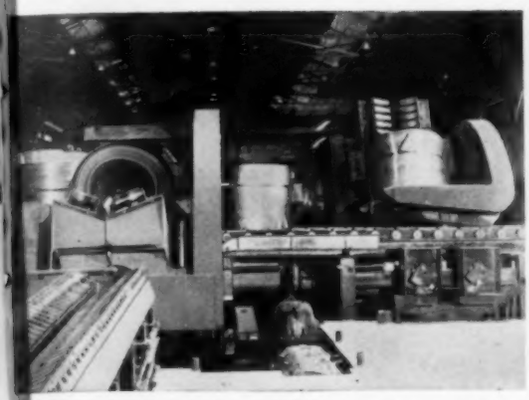


1 Along every step of the way—in every process—Link-Belt can help you cut costs with modern materials handling machinery. See a typical example, above. Here, Link-Belt Car-Type Conveyors economically move coils of hot strip around corners and down inclines—all without rolling or scuffing edges.

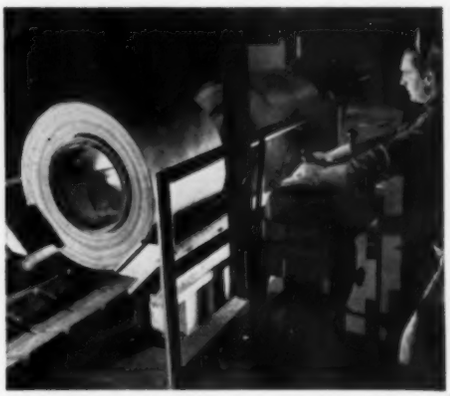
Link-Belt is materials handling headquarters. Working hand-in-hand with your own engineers, consultants, and builders of mill and process equipment, Link-Belt engineers can help you solve your mechanization problems. Write direct or contact your nearest Link-Belt representative.

GREATER YIELD

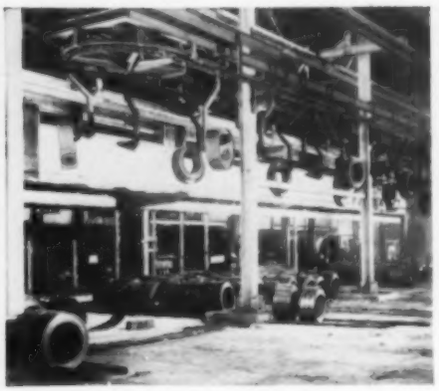
LINK-BELT can help you increase output in your present plant with modern mechanization



2 Greater yield comes from gentler handling. Link-Belt Down-Tilters and Transfers are designed to provide smooth, controlled manipulation of hot coils and increase mill yield by reducing scrap.



3 Link-Belt Conveyors provide controlled storage ahead of pickle lines, cold mills and other processes. This is essential for scheduling and to eliminate the confusion of vehicles and the hazard of overhead cranes.



4 Link-Belt Overhead Trolley Conveyors create added work-area on floors of existing plants — are readily adaptable to irregular paths and building structures for carrying and cooling coils of narrow strip, rod and wire.

5 Link-Belt can step up your raw materials storage and handling operations — permit the storing of more materials in the same area ... storing at higher tonnage rates ... reclaiming at increased handling rates.

6 Specially developed Link-Belt Chains take brutal punishment year after year in the nation's steel mills. Standard types are available for basic elements of complete handling systems or power transmission.

7 Link-Belt Herringbone Gear Drives are engineered to take heavy shock loads dependably and continuously. Yes — wherever power is to be transmitted mechanically, Link-Belt offers a full range of gear and chain drives.

AT THE A. I. S. E. CONVENTION

On your trip to U. S. Steel's Gary Sheet and Tin Mill on October 2, be sure to see the coil handling equipment from the 80-inch hot mill. Link-Belt equipment used in this mill includes the conveyors, waffle-type loaders from coilers, lift and turn units and unique side-discharge down-tilters.

12,208

LINK-BELT

Materials Handling, Processing and Power Transmission Machinery

LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Cleveland 15, Pittsburgh 13, Atlanta, Dallas 1, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

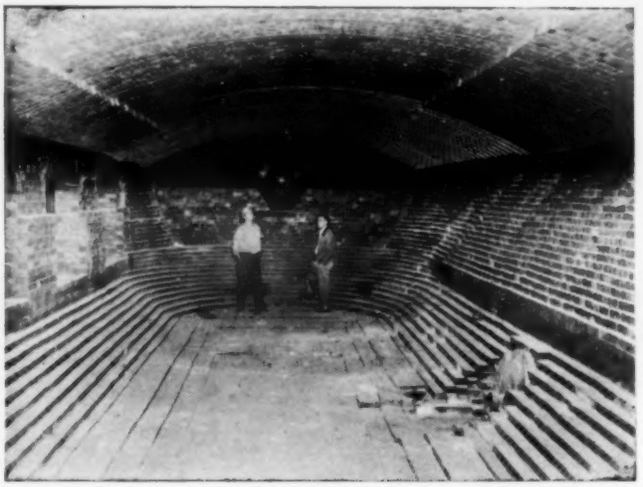
It's H-W MAGNAMIX 100%!

A Basic Ramming Mixture for furnace bottoms, and for maintenance

Steel can be made on an H-W MAGNAMIX bottom within a few days after hearth construction is begun, with great savings in time and labor, and with increased production from the furnace. The technique of its use is such that the risk of overheating with consequent damage to the furnace structure can be avoided.

The high-magnesia content of H-W MAGNAMIX provides the durability required for open-hearth service. When solidly rammed, H-W MAGNAMIX bottoms contain about 130 pounds of magnesia per cubic foot, largely in the form of the mineral, periclase, the durable constituent of magnesite furnace bottoms.

H-W MAGNAMIX is used with outstanding success for maintaining and repairing flats, banks, and tap holes of basic open-hearth furnace bottoms, for hot patching and for routine maintenance. It is also the accepted standard at many electric steel furnace plants for the construction of basic furnace bottoms.

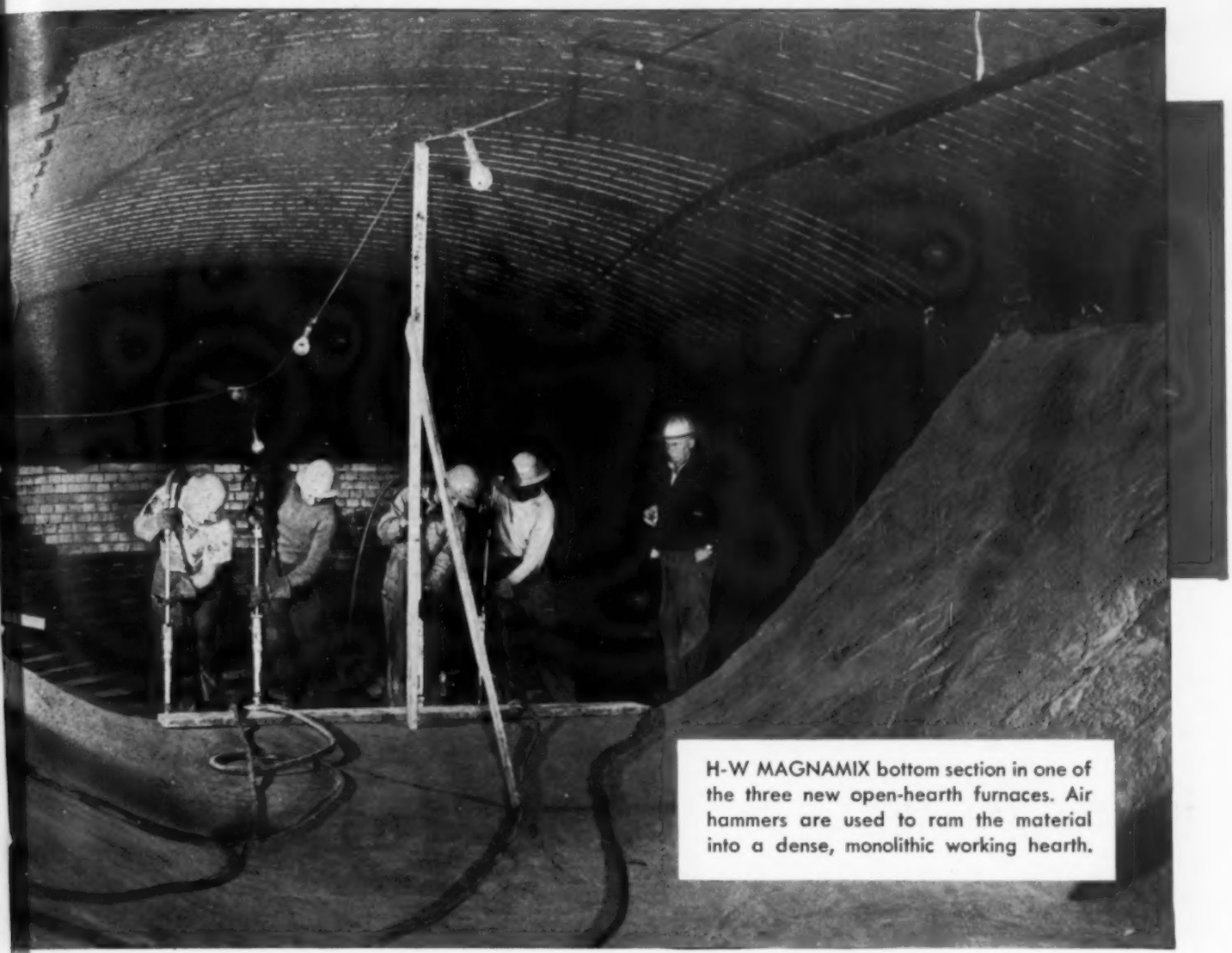


Interior view of one of the furnaces ready for the installation of the H-W MAGNAMIX bottom.

H-W MAGNAMIX is shipped dry, in convenient 100-pound sacks. It is prepared for use by mixing with water to the proper consistency, and is applied by ramming to the desired contour. After the hearth is installed, it is dried and then heated to the sintering temperature. The result is a dense, impermeable structure consisting mainly of periclase.

Harbison-Walker Refractories Company

AND SUBSIDIARIES



H-W MAGNAMIX bottom section in one of the three new open-hearth furnaces. Air hammers are used to ram the material into a dense, monolithic working hearth.

Selected for ALL THREE furnace bottoms in completely NEW open-hearth shop

This is another example of complete endorsement of H-W MAGNAMIX by a leading producer of steel. Extensive experience previously with H-W MAGNAMIX bottoms was exceedingly satisfactory. Accordingly when this new shop was planned, H-W MAGNAMIX was selected for the bottoms of all three furnaces which embody the most modern features of engineering design and construction.

The long list of open-hearth furnaces in which H-W MAGNAMIX is used includes those of the country's largest producers of steel. Results achieved confirm the judgment and experience of the producer who is using H-W MAGNAMIX *exclusively* for the new furnace bottoms.

WORLD'S LARGEST PRODUCER OF REFRACTORIES

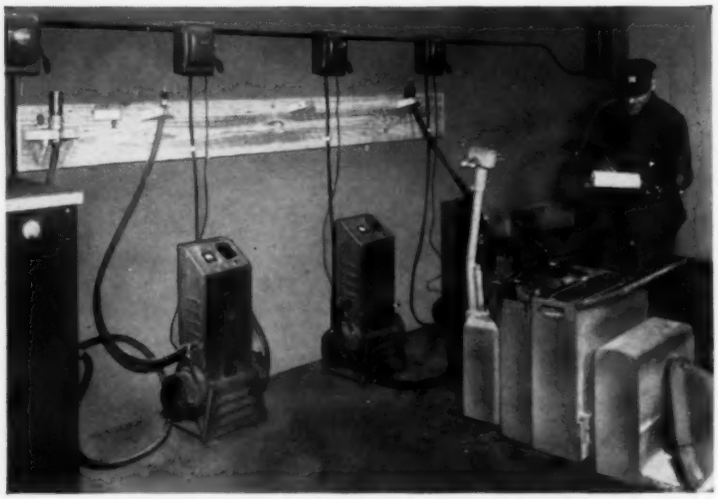
General Offices . . . Pittsburgh 22, Pennsylvania

GOULD

Plus-Performance Plan

. . . SHOWS YOU HOW

CORRECT CHARGING EXTENDS BATTERY PERFORMANCE!



Charging rooms should be planned to make charging and handling convenient and economical.

Right now, the problem of conserving and extending essential battery power is urgent. Timely help is offered you by the GOULD PLUS-PERFORMANCE PLAN which can improve battery performance as much as 50%! Here is a complete system of manuals, articles, specifications, bulletins, record cards and charts which explains and illustrates how to select, charge and handle, maintain and determine the condition of your batteries.

The material comprising the GOULD PLUS-PERFORMANCE PLAN is available to battery users without obligation. A request on your letterhead will bring descriptive literature by return mail.

The Gould "Thirty" with "Z" Plates—America's Finest Industrial Truck Battery

FOUR SIMPLE CHARGING RULES SAVE POWER

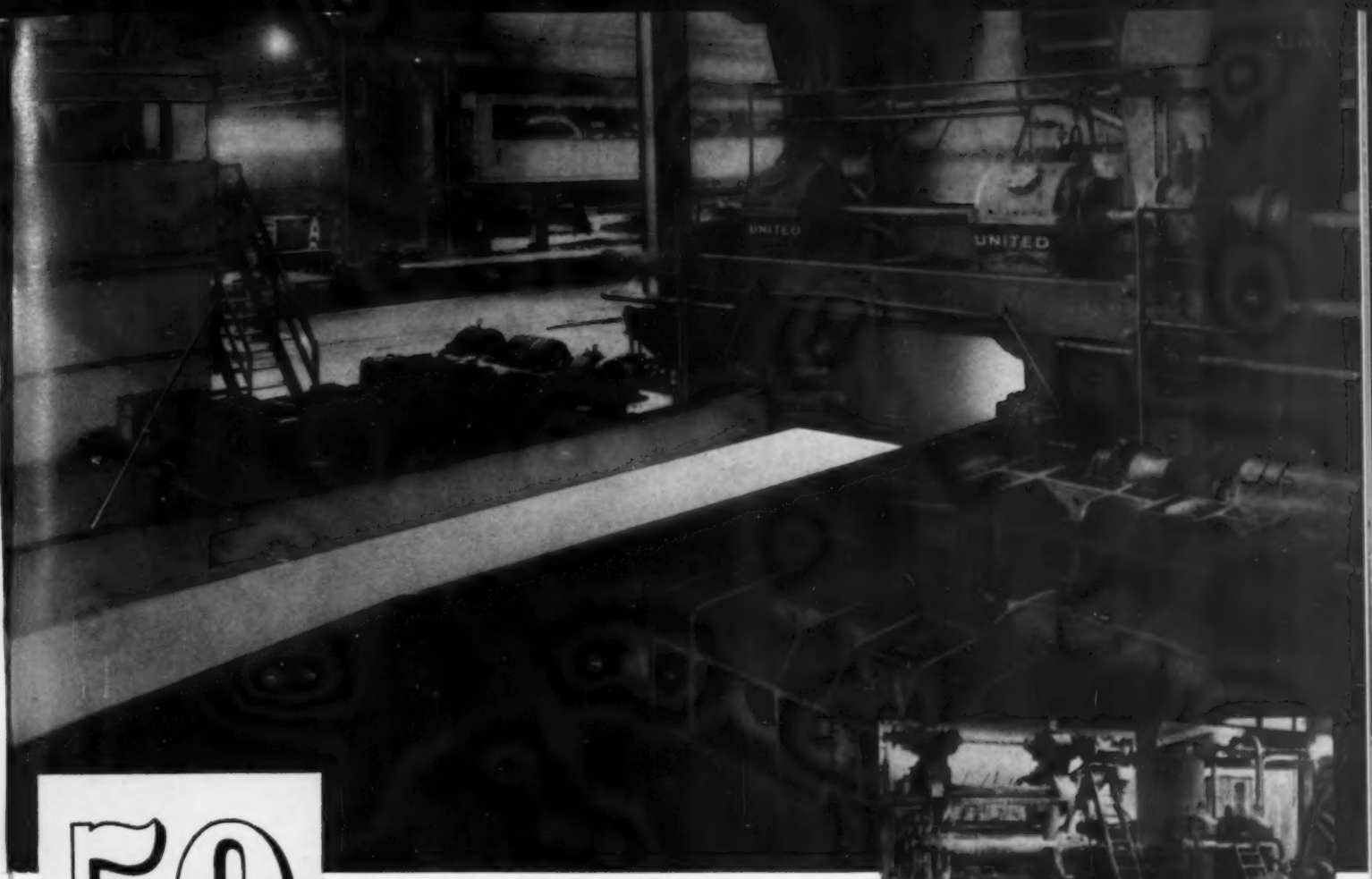
1. Do not overcharge. Use 22.5 amperes per 100 ampere-hours of battery capacity for 80% of charging time. Finish charge at 5 amperes per 100 ampere-hours. Correct charging will not cause gassing or overheating.
2. Give periodic equalizing charges. An extra 4-hour charge at the recommended finish rate at least once a month but not more often than once a week makes sure all cells are up to full charge.
3. Keep idle batteries charged. Batteries not in use should be given a freshening charge once every three months to prevent internal discharge, sulphating and eventual loss of efficiency.
4. Inspect charging equipment regularly. Make sure it is set correctly for the size of batteries to be charged. Inspect voltage relay timers frequently to assure accurate automatic cut-off. If ampere-hour method is used, check ampere-hour meter charts for correct settings.

GOULD

STORAGE BATTERIES

GOULD-NATIONAL BATTERIES, INC., TRENTON 7, NEW JERSEY

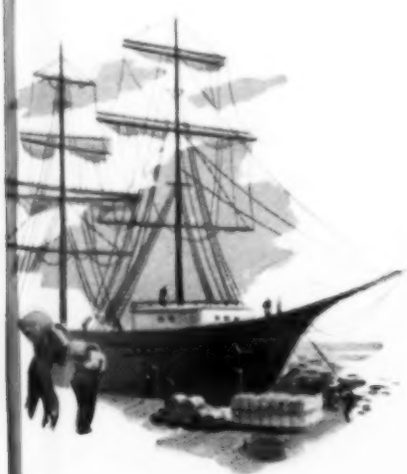
Always Use Gould-National Automobile and Truck Batteries



Modern United 120" Plate Mill

Plate Mill
of about
50 Years Ago

50 YEARS AGO much of the World's Commerce was Carried in Wooden Ships



DEVELOPMENT of modern steel rolling equipment, such as the United plate mill shown above has made possible construction of the great all-steel ships that carry today's enormous seaborne tonnage.

As a major supplier of equipment for the steel industry, United is proud to have had a part in the development of metal rolling processes that have helped to render obsolete the wooden hulls of other days. A more evident example of progress would be hard to find. Steel is the framework of civilization.

UNITED

ENGINEERING AND FOUNDRY COMPANY

Pittsburgh, Pennsylvania

Plants at PITTSBURGH • VANDERGRIFT • NEW CASTLE • YOUNGSTOWN • CANTON

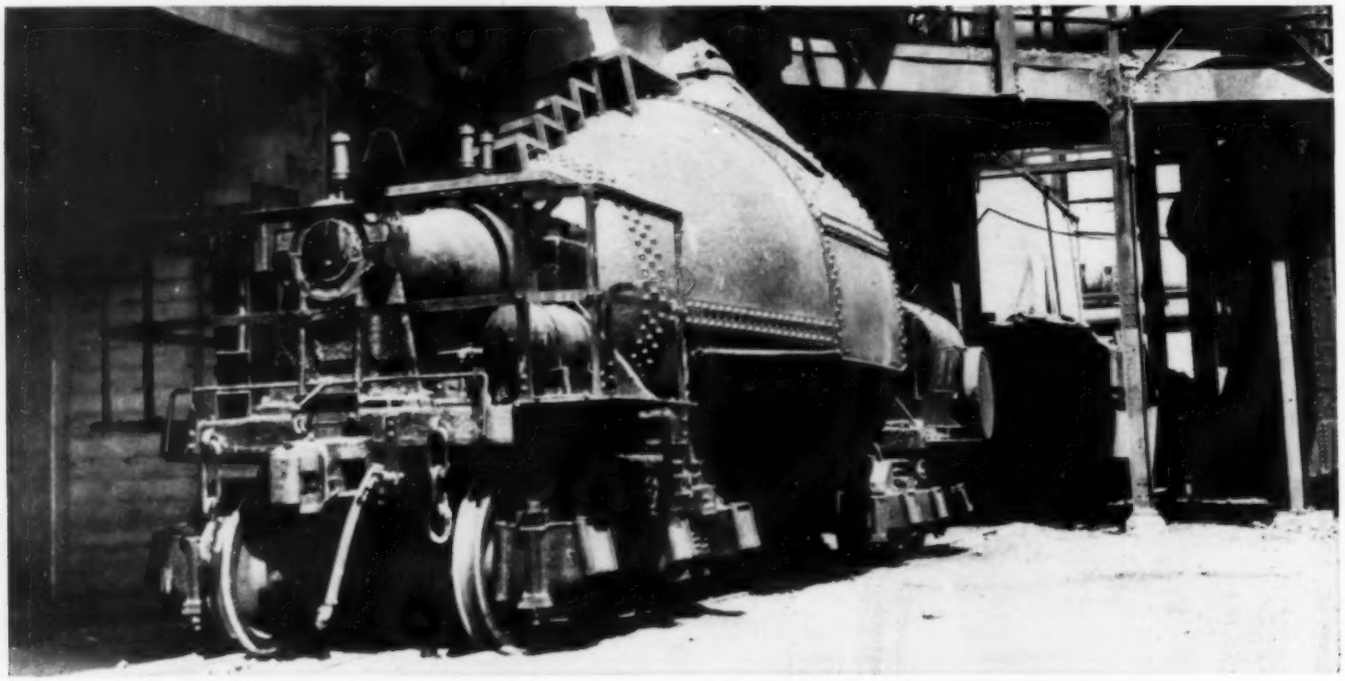
Subsidiaries:

ADAMSON UNITED COMPANY, AKRON, OHIO
LOBDELL UNITED COMPANY, WILMINGTON, DELAWARE
STEDMAN FOUNDRY AND MACHINE CO., INC., AURORA, INDIANA

Golden Anniversary
1901 UEFCO 1951

FOUR TASIL LINED TREADWELL LADLES

Set NEW TONNAGE RECORD in Pittsburgh District!



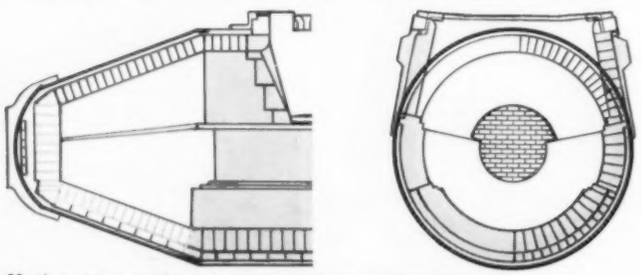
To keep a ready supply of hot metal available "BALANCE" your linings with TASIL!

RESULTS OF RECENT TEST — Pittsburgh District

LINING	AVERAGE TONNAGE BEFORE RELINED
Blast Furnace Quality Fire Brick	35,000 to 60,000 Tons
Super-Duty Fire Brick	138,166 Tons
TASIL "Balanced" Super-Duty Brick	168,305 Tons*

*Average of 4 linings.

TASIL "BALANCED" TREADWELL LADLE LINING



Half-section and vertical section on center line.

▭ - TASIL Brick and Cement

TAYLOR SILLIMANITE (TASIL) Brick and Cement extend the service life of Treadwell, Cling, and similar types of hot metal cars or ladles when used to reinforce or "balance" critical areas (see sketch). TASIL brick will not shrink or vitrify at service temperatures. Tough—they withstand the washing action of molten iron during charging, transportation and pouring.

TASIL No. 301 Air-Setting or No. 302 Heat-Setting Cement makes permanent weld-like joints and retards joint erosion. Used successfully with TASIL, bonded mullite or super-duty brick linings.

In the above test, four TASIL "balanced" ladles carried 158,017 tons, 170,156 tons, 179,609 tons and 165,432 tons respectively. The average tonnage was 21-4/5% greater than that of all super-duty brick linings. TASIL brick projected 1½" beyond adjoining super-duty fire brick when cars were taken out for re-lining.

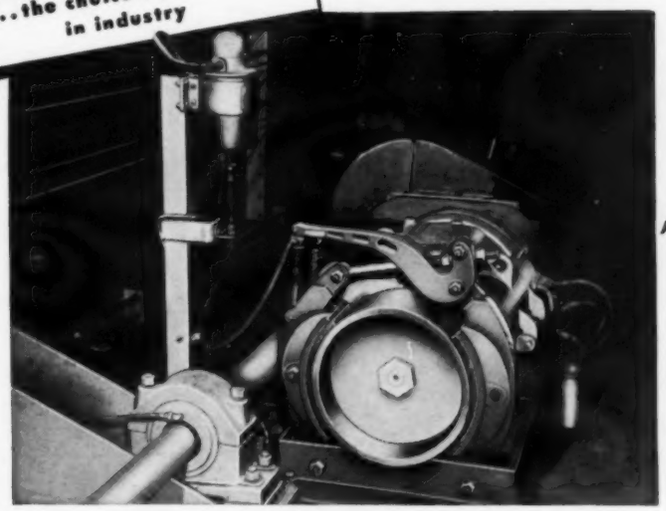
Keep your ladles and hot metal mixers working, reduce masonry and refractory costs, keep hot metal available at the Open-Hearth—use TASIL Brick and Cement to "balance" your linings. Bulletins 314 and 315 give complete data. Write for your copies.

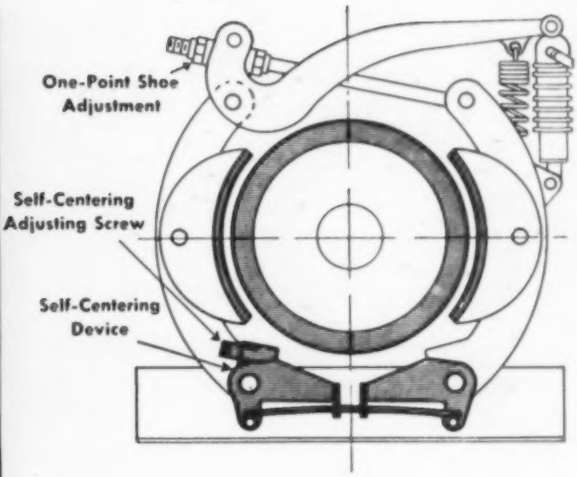
Refractorers to industry since 1864.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

The CHAS. TAYLOR SONS Co.
MANUFACTURERS OF REFRACTORIES • CINCINNATI • OHIO • U.S.A.

Wagner
CRANE-BRIDGE BRAKES
...the choice of leaders in industry





Only Wagner can give you all these features that mean *safe, sure stops for cranes*

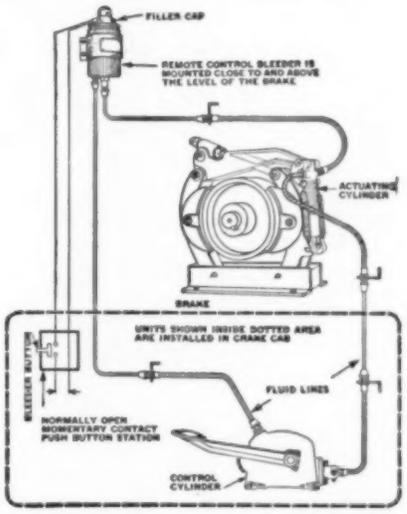
Wagner Crane-Bridge Brakes are HYDRAULIC—they let you stop your cranes the way you stop your car . . . with *full control* . . . and with utmost safety. Wagner Hydraulic Brakes provide even the heaviest steel mill ladle cranes with controlled deceleration and smooth, precise stops.

Only Wagner Hydraulic Braking Systems are equipped with the remote control bleeder that keeps the lines full of fluid and makes bleeding the system a simple "one-man one-minute" job, and only Wagner offers the self-centering device that prevents brake shoe drag by automatically assuring equal clearance of both shoes.

Other features include power failure braking, one-point shoe adjustment, 200% emergency torque, and non-scoring molded lining blocks that are easily replaceable.

You can handle any crane bridge braking application with Wagner Hydraulic Brakes—four sizes, with or without parking attachment, cover the field.

If your cranes are not equipped with Wagner Brakes, we can show you how simple it is to install a modern hydraulic system. If you still have old-style Wagner Brakes, your system can be easily modernized with our complete conversion kits. Bulletin IU-40 gives full information—write for your copy.


FILLER CAP
REMOTE CONTROL BLEEDER IS MOUNTED CLOSE TO AND ABOVE THE LEVEL OF THE BRAKE
ACTUATING CYLINDER
BRAKE
UNITS SHOWN INSIDE DOTTED AREA ARE INSTALLED IN CRANE CAB
BLEEDER BUTTON
FLUID LINES
NORMALLY OPEN MOMENTARY CONTACT PUSH BUTTON STATION
CONTROL CYLINDER

Controlled from the crane cab, the bleeder enables the operator to remove air from the fluid lines whenever necessary, simply by pressing a pushbutton and pumping the control cylinder foot pedal.

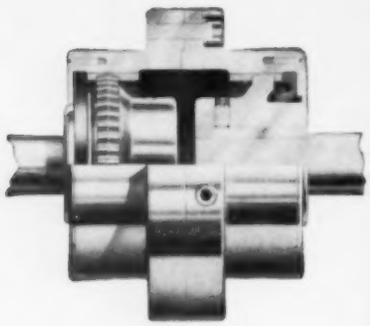
WAGNER ELECTRIC CORPORATION
6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

Wagner Electric Corporation
1891 WE 1951

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 31 PRINCIPAL CITIES

IU-2



NEW AJAX DIHEDRAL COUPLING CAN BE LINED UP WITH YOUR EYE

Handles Misalignment Heretofore Considered Excessive

Introduction of the new Ajax Dihedral Coupling is saving thousands of hours and dollars all the way from machine design to actual installation and maintenance. The ability of Ajax Dihedral Couplings to handle misalignment heretofore considered excessive is based on the exclusive tooth shape which permits handling shaft misalignment far beyond the capacity of conventional flexible couplings.

Tooth clearance (backlash) in Ajax Dihedral Couplings is kept to oil film requirements.

Difficult misalignment problems are eliminated under conditions of settling foundations, old or inadequate wooden floors, weaving chassis or structural mountings.

Standard Dihedral Couplings are made to handle misalignment up to 7°. Teeth can be cut to handle greater misalignment but each job must be engineered.

Write for Bulletin 50.

AJAX KNOWS COUPLINGS

Working Hand-in-Hand With America's Leading Manufacturers and Users of Direct-Connected Machines for Thirty Years . . .

AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, NEW YORK

This . . . . . WILL FIT INTO *your* MILL PICTURE

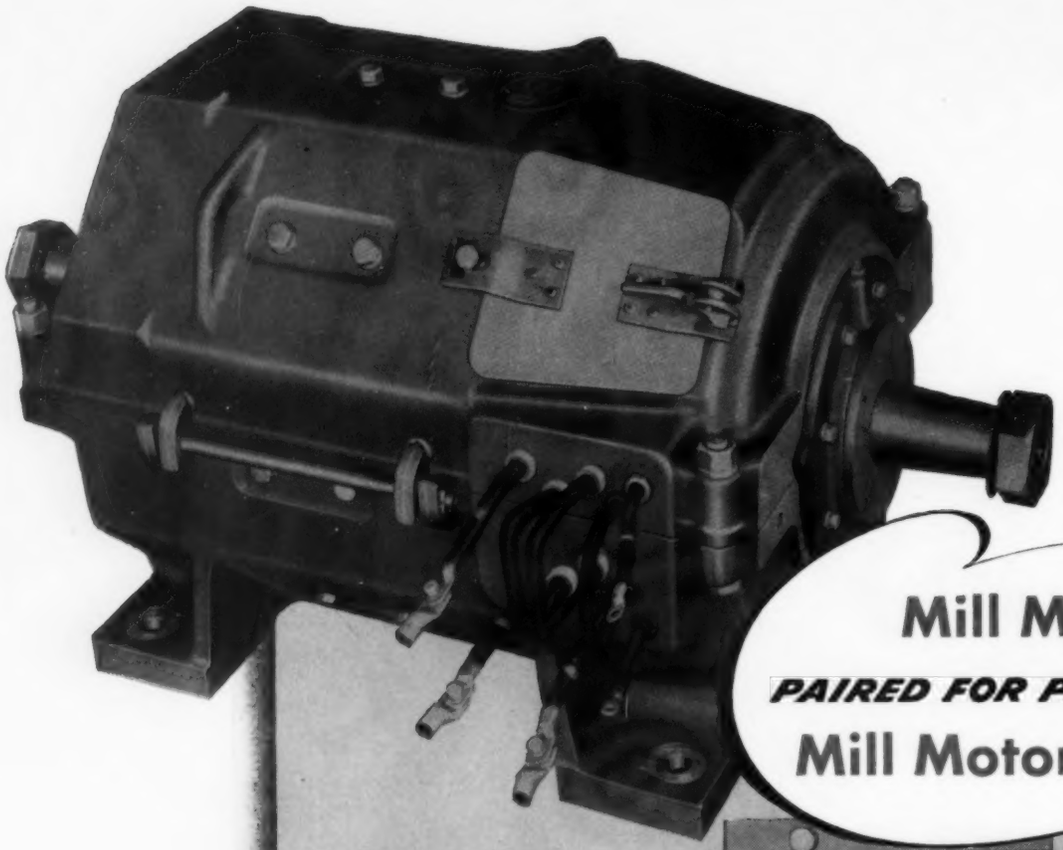
LEWIS ROLLS

"X" AND "XA"
PLAIN CHILLED IRON
MOLYBDENUM CHILLED IRON
SUPERIOR "X"
ATLAS AND ATLAS "X"
SPECIAL PROCESS
AJAX DUPLEX
CLIMAX AND AJAX
SPECIAL TUBE MILL ROLL

MANUFACTURERS OF
ROLLS AND ROLLING MILL EQUIPMENT
FOR THE IRON, STEEL AND
NON-FERROUS
INDUSTRIES

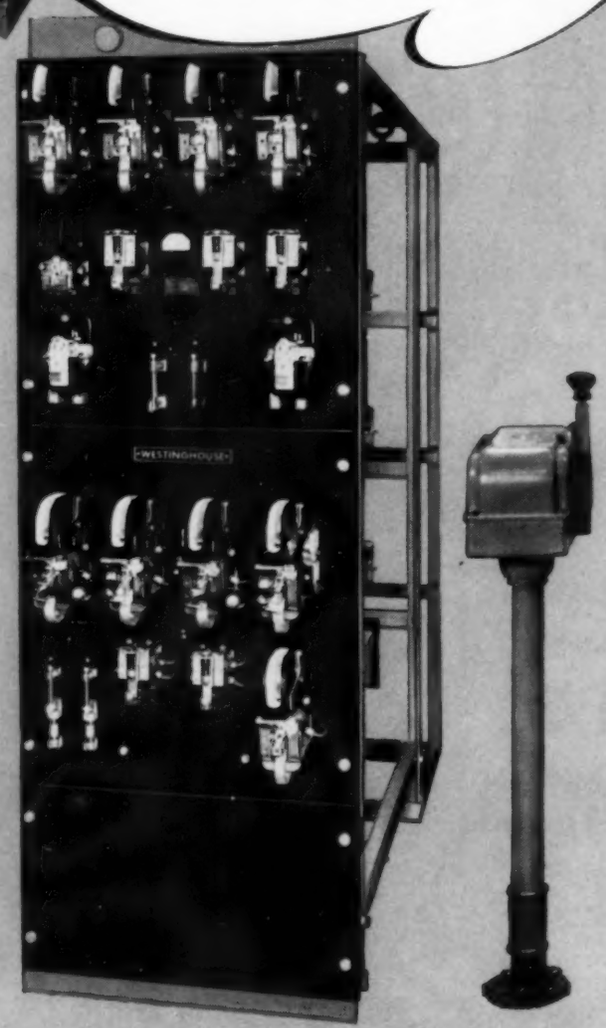
*The mark of a
PERFECT ROLL

LEWIS FOUNDRY AND MACHINE DIVISION OF BLAW-KNOX COMPANY • PITTSBURGH, PA.



Mill Motor
PAIRED FOR PRODUCTION
Mill Motor Control

600 Series Mill Motor



Typical 9500
Line Controller, Type M
Contactors and Type SM
Master Switch

Rugged!

cut mill down time with this team

Certainly in a mill, where down time costs add up fast, the ability of equipment to stand up to rugged continuous duty is of paramount importance. That's why you'll find this combination hard to beat. They are rugged . . . made together to work together. Each incorporates the latest design features to keep production lines rolling.

Take the motor for example. The high starting torque of this new 600 series mill motor is ideal for high inertia loads . . . proved commutation . . . high rated efficiency assures maximum performance under tough service conditions . . . simplified construction makes servicing and maintenance easy. It is a brand-new motor with a new kind of performance built for today's tougher jobs.

Controllers, too, are built to assure new dependability. Main contactors are the new Type M with knife-edge, trouble-free bearings . . . with exclusive Quick-Quench arc boxes which greatly increase contact life. Overload relays are the dual thermal instantaneous type. Accelerating relays are the time-proved inductive time delay Type AZ.

The third part of this control team is the rugged Type SM master switch. Easy to operate, yet with a definite "feel" for each operating point of position, the switches are available with 2 to 6 speed control.

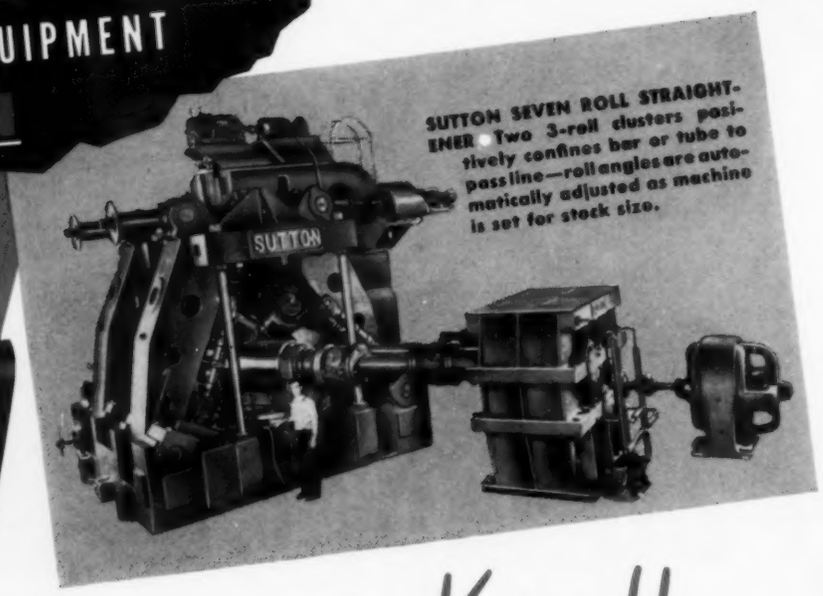
Together, these three offer a new kind of dependability. Get the facts on all three. Ask your nearby Westinghouse representative for a copy of the new booklet B-4730, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21647

YOU CAN BE SURE.. IF IT'S

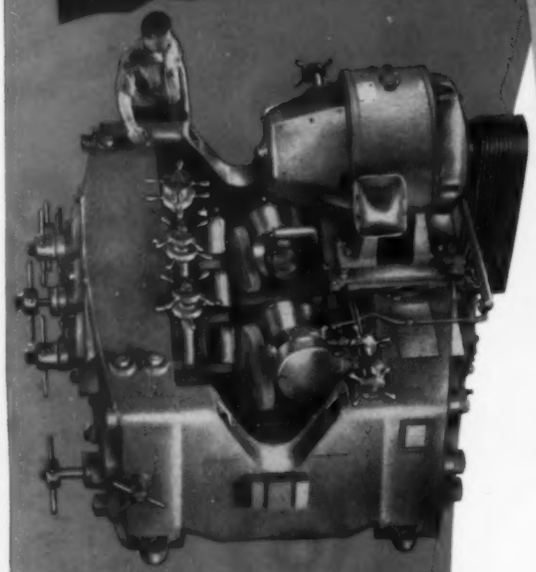
Westinghouse

MILL MOTORS AND CONTROLS

STRAIGHTENING EQUIPMENT by—SUTTON



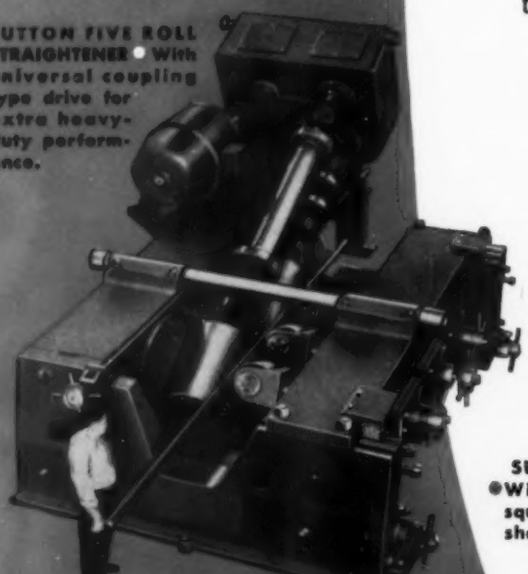
SUTTON SEVEN ROLL STRAIGHTENER • Two 3-roll clusters positively confines bar or tube to pass line—roll angles are automatically adjusted as machine is set for stock size.



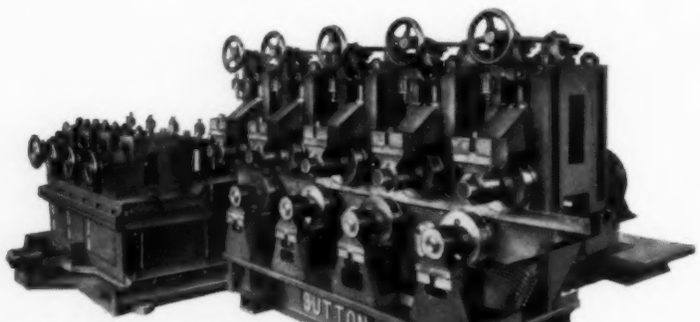
SUTTON FIVE ROLL STRAIGHTENER • With direct gear drive—especially adapted to high speed straightening of bars and tubes.

..... it's the *Know How* that counts

Sutton has specialized in straightening equipment for 35 years! Sutton Straightening Machines are built in all sizes for bars and tubes from ⅛" to 18" in diameter and operate at speeds up to 1000 feet per minute. Pictured are representative examples.



SUTTON FIVE ROLL STRAIGHTENER • With universal coupling type drive for extra heavy-duty performance.



SUTTON TWO-WAY STRAIGHTENER • With outboard bearings—for flats, squares, hexagons, angles, and other shapes.

Write for a proposal or for specific information in answer to any straightening problem you may have. There is no obligation for this service.

SUTTON *Engineering* COMPANY

***Manufacturers for* Ferrous and Non-Ferrous Industries**

STRAIGHTENERS, SHEET LEVELLERS, HYDRAULIC STRETCHERS, GAG PRESSES, ROTARY CLEANERS, HEAVY DUTY UNIVERSAL JOINTS, ROLLS

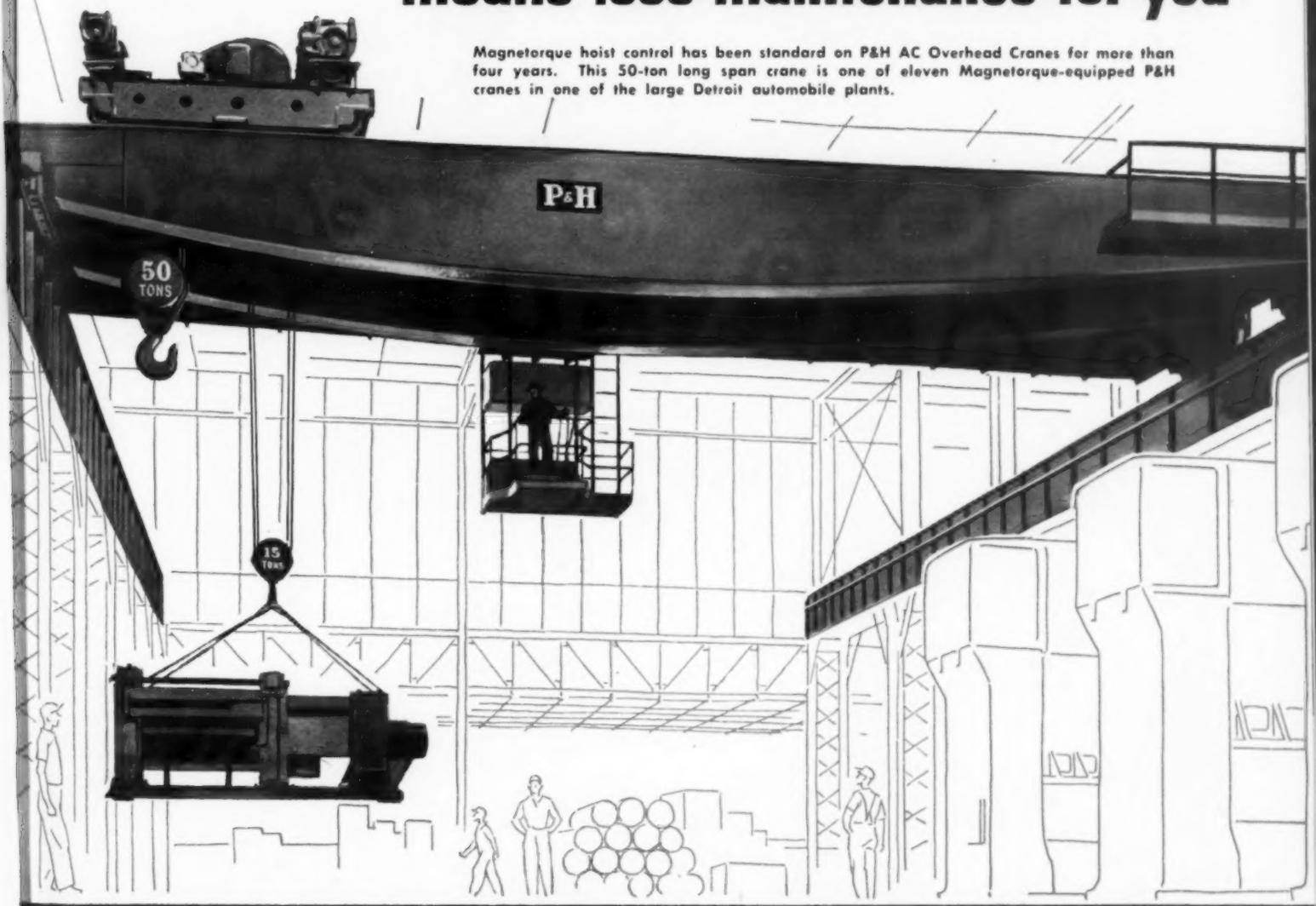
BELLEFONTE, PENNSYLVANIA

P&H OVERHEAD CRANES

MAGNETORQUE*

means less maintenance for you

Magnetorque hoist control has been standard on P&H AC Overhead Cranes for more than four years. This 50-ton long span crane is one of eleven Magnetorque-equipped P&H cranes in one of the large Detroit automobile plants.



P&H Magnetorque AC hoist control operates electro-magnetically — without friction or wear. It eliminates the mechanical load brake with its need for adjustment and relining. Trouble-free and dependable, Magnetorque gives you smoother speed regulation than is possible with DC dynamic control *under all load conditions.*

With Magnetorque 5-step full magnetic or 8-step drum control, inaccurate "inching" for fractional lowering or hoisting is unnecessary. It operates on both hoisting and lowering. All this — and lower maintenance — is yours when using Magnetorque with your convenient AC power supply.

P&H Overhead Cranes serve you best when you have *all* the genuine P&H components — controls, motors, switches, P&H *balanced design* assures most efficient operation.

*T.M. of Harnischfeger Corporation for electro-magnetic type brake.

OVER 17,000
P&H CRANES
SERVE AMERICAN INDUSTRY...
FAR MORE THAN ANY OTHER

P&H

"job engineered" to fit your needs

P&H

OVERHEAD CRANES

4455 W. National Avenue
Milwaukee 14, Wisconsin

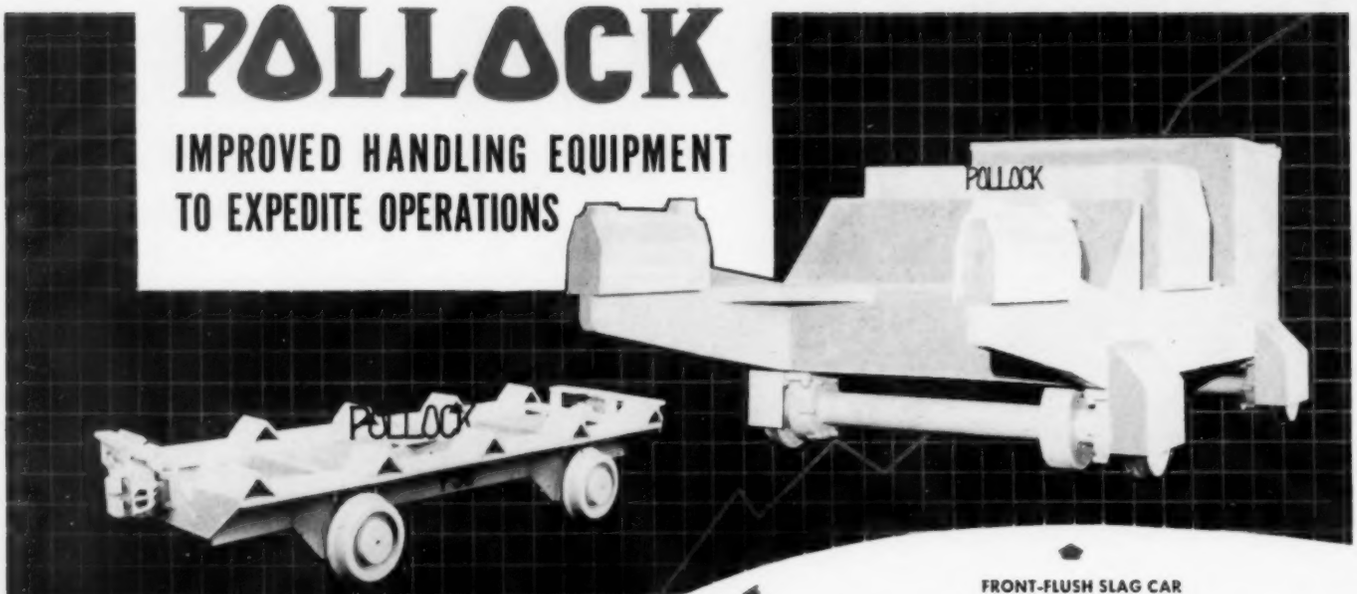
HARNISCHFEGER CORPORATION

P&H

SHOVELS • CRAWLER AND TRUCK CRANES • OVERHEAD CRANES • HOISTS • ARC WELDERS AND ELECTRODES • SOIL STABILIZERS • DIESEL ENGINES • PRE-FAB HOMES

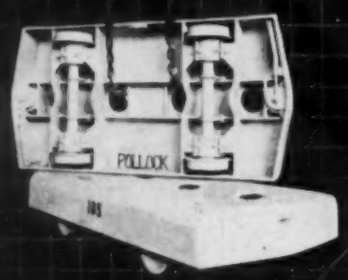
POLLOCK

IMPROVED HANDLING EQUIPMENT TO EXPEDITE OPERATIONS

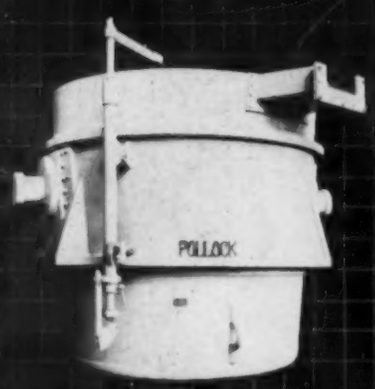


FRONT-FLUSH SLAG CAR

CHARGING BOX CAR



INGOT CAR



OPEN HEARTH LADLE

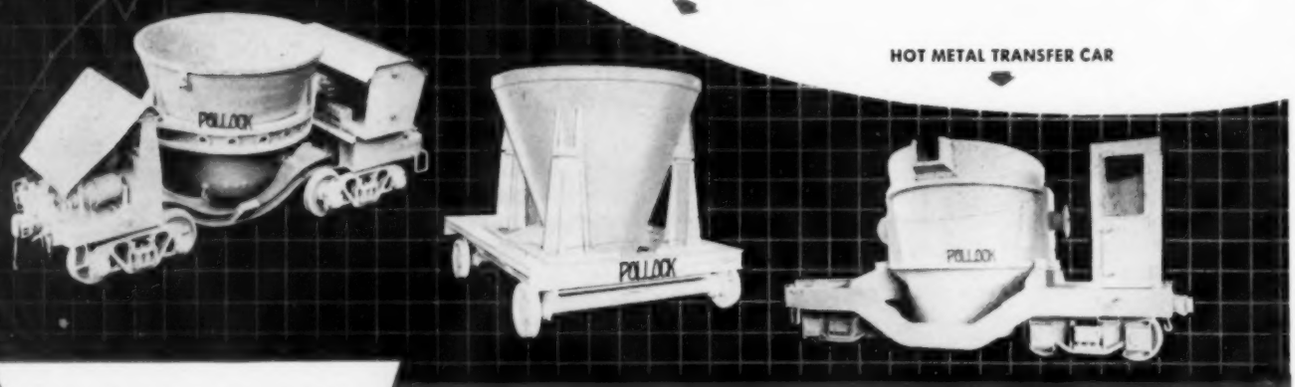
SLAG CAR

an important factor in increased open hearth production

• Pollock experience in the development and construction of open hearth equipment assures smooth flow of operations. To measure use-value of Pollock handling equipment, add their day by day engineering research to 85 years of producing for the steel industry. General specifications available on request. Special-performance details engineered for your needs.

DRAG-OUT SLAG CAR

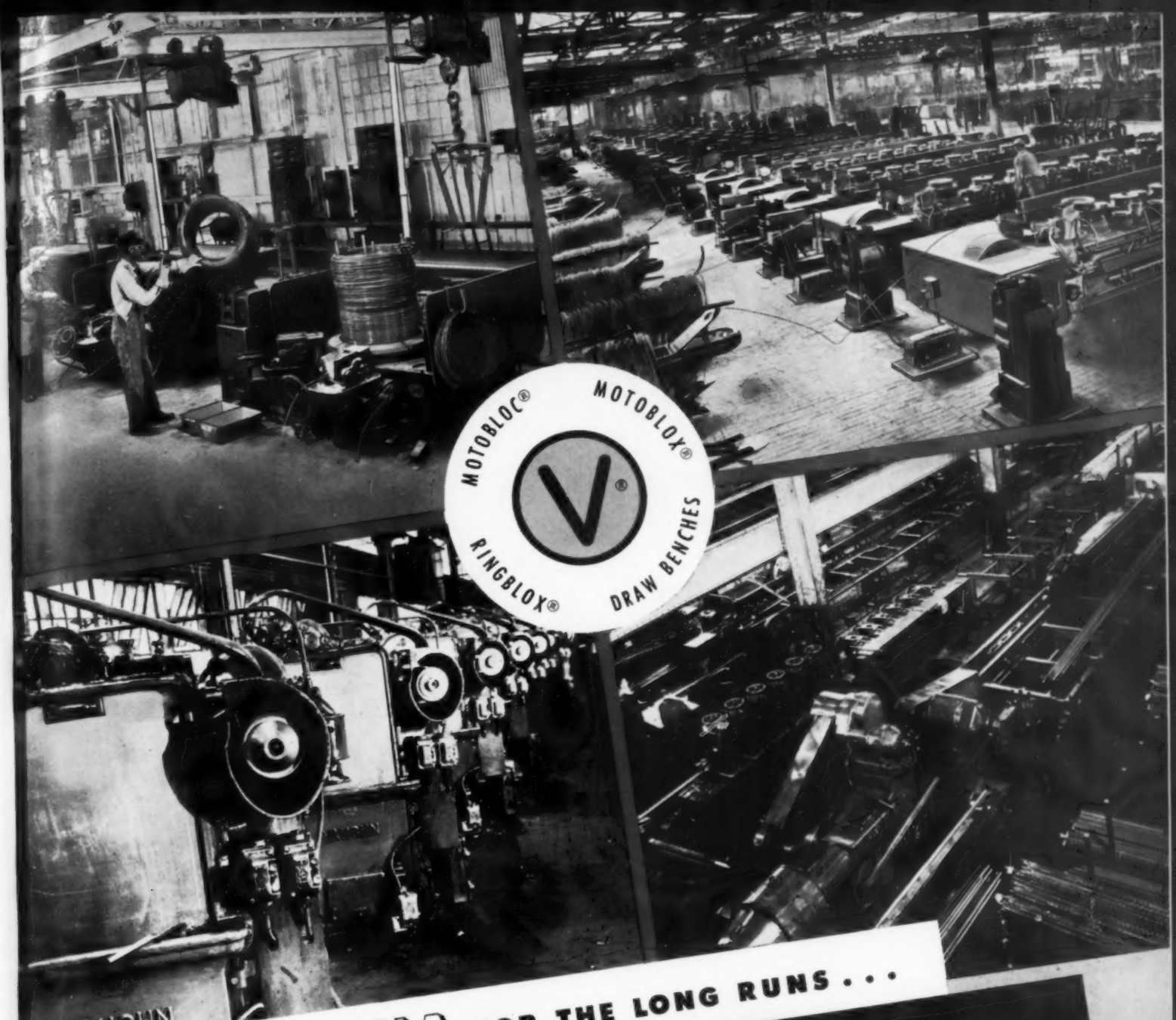
HOT METAL TRANSFER CAR



POLLOCK
SINCE 1863

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN · OHIO
STEEL PLATE CONSTRUCTION · ENGINEERS · FABRICATORS · ERECTORS

BLAST FURNACES · HOT METAL CARS AND LADLES · CINDER AND SLAG CARS · INGOT MOULD CARS · CHARGING BOX CARS · WELDED OPEN HEARTH LADLES



STAMINA FOR THE LONG RUNS . . .

Versatility FOR THE SHORT!

Vaughn Cold Drawing Machinery takes care of your production as *it comes*— speedily, safely, efficiently, at minimum operating cost. Whether your need is for wire, bars, tubes or special shapes, you'll find the *right* equipment bears the Vaughn nameplate. *WRITE!*

THE VAUGHN MACHINERY CO.

CUYAHOGA FALLS, OHIO, U. S. A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

Vaughn®

COLD DRAWING MACHINERY

blast furnace skip-hoist drive

cuts skip-cycle time, simplifies speed control!

Dual motor-and-generator drive—G-E engineered and G-E equipped—holds constant speed regardless of load, provides faster acceleration and deceleration, lengthens machine and rope life!

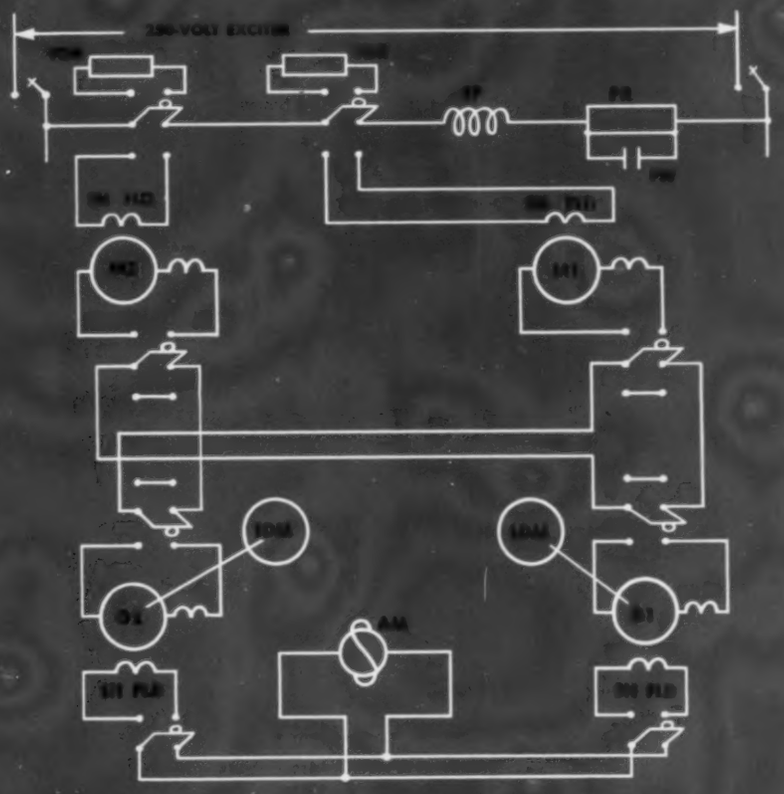
Utilizing the quick response and versatility of the G-E amplidyne, this skip-hoist drive employs two shunt-wound, 150-hp G-E mill motors designed for "field-forcing" to drive the hoist drum. With the motors connected to two generators, excited by the amplidyne, the drive provides these outstanding advantages:

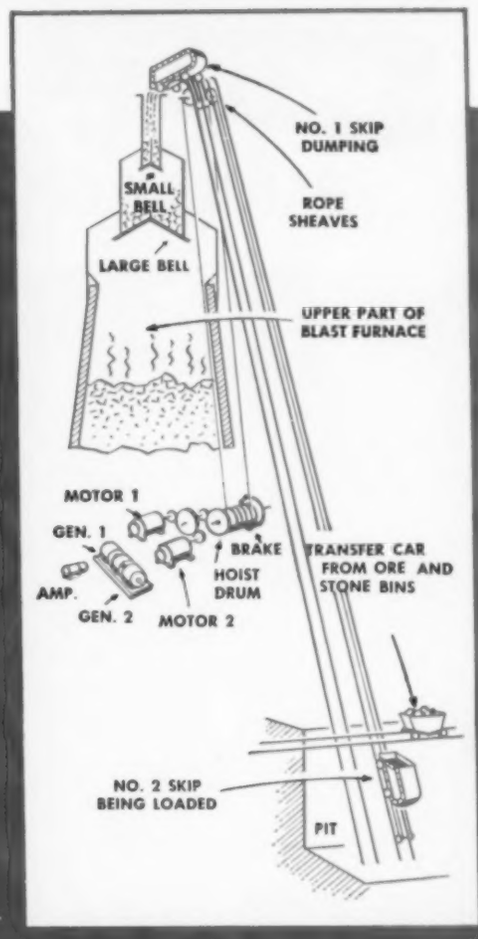
- **Continuity of operation in an emergency.** Hoist may be operated with either motor or either generator, or with one set shut down, without too great a reduction in hoist output.
- **Constant hoist operating speed, regardless of load carried.**
- **Equal division of load between machines.**
- **High starting torque per ampere of armature current.**
- **Simplified control.** Numerous armature and field contactors are avoided.
- **Faster acceleration and deceleration of the skip.** Accelerating current is maintained substantially constant. This reduces over-all skip-cycle time and increases hoise output.
- **A wide range of operating speeds.** This permits close co-ordination of skip-hoist action with furnace needs.
- **Reduced mechanical stress on machinery and haulage ropes.** Longer equipment life is obtained because of the amplidyne's current and torque limit control.

This engineered drive is one more illustration of the advantages of calling us in on your drive problems. Let a G-E specialist discuss complete blast furnace electrification with your technical men. Today, a well-engineered and co-ordinated electrical system is a necessity for continuity of your blast furnace operation. *General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

659-58





GENERAL SCHEME OF BLAST FURNACE SKIP HOIST

HERE'S THE ELECTRICAL STORY BEHIND THIS NEW G-E DRIVE:

As shown schematically above, the skip hoist is driven by two shunt-wound mill type motors (M1 and M2), with their armatures electrically connected in series with generator armatures (G1 and G2). Full speed and slow-down speed of the hoist are controlled by automatically adjusting the armature voltage of the generators. The hoist is started from push-button stations on the master control unit in the stock house, or from a master switch in the skip house. When the hoist starts, the shunt fields of the motors are "forced," to obtain maximum torque per ampere of armature current. High starting torque is necessary because of the unbalanced rope pull existing when the loaded skip is in the pit.

The pre-selected operating speed of the hoist is controlled by a control field in the amplidyne exciter (AM1). Another control field in the amplidyne exciter limits the armature current of the generator. When the skip bucket approaches the dumping knuckle, it is automatically slowed down by a limit switch to a preset speed. This speed is substantially the same whether the load is heavy iron ore or light coke. This limit switch also controls the stopping of the hoist.

Transfer knife switches are provided so that either motor and generator may be disconnected quickly and the hoist operated with normal loads at reduced speed.

another example of
GENERAL ELECTRIC
drive engineering at work!

SPEED UP *Mass Production of Steel with*

BIRDSBORO BLOOMING MILLS

If this is your Problem— Mass production of high quality stainless, high speed, automobile and special purpose alloy steels with minimum labor costs.

Here is the Solution— This 2-high, rapid reversing 26-in. blooming mill with fast screw-down and rapid manipulation, operated by two men.

• Birdsboro's engineering facilities make possible the design and construction of "custom-built" blooming mills which, today, are helping many manufacturers catch up with the demand for all types of durable goods.

Let our engineers go to work with yours in the planning stage and, in this way, come up with a practical solution that will speed production as well as hold down operating and maintenance costs.

BIRDSBORO
STEEL FOUNDRY & MACHINE CO.
Birdsboro, Penna.

Offices in BIRDSBORO, PA. *and* PITTSBURGH, PA.

STEEL MILL MACHINERY

Designers and Builders of:
Steel Mill Machinery • Crushing Machinery • Rolls
Hydraulic Presses • Special Machinery • Steel Castings

MM 19-51

piping repairs *cost more* now!

Crane No. 351 125-Pound
Iron Body Globe Valve

You make fewer of them

by using Dependable Quality

CRANE VALVES

...That's why more Crane Valves are used than any other make

Preferred for true, tight seating

For smooth, positive regulation of flow, check Crane quality engineered Iron Body Globes with composition or metal disc. They're easy to operate; easy to maintain. Guide stem under disc assures square seating ... true disc travel with minimum vibration. Seat rings are screwed in and can be renewed if necessary.

These rugged valves require little maintenance. Roomy stuffing box with bolted two-piece gland keeps tight stem seal, lengthens packing life. Stem threads are outside valve body, easy to lubricate.

Ask your Crane Representative to show you how Crane Quality valves and fittings not only give you more dependable piping performance ... but cost less in the long run.

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

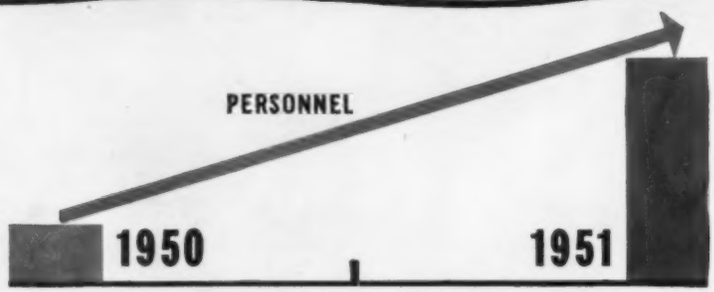
FROM

FREYN DESIGN

TO

FREYN DESIGN

in One Year!



FREYN ENGINEERING HAS ASSIMILATED AND ORGANIZED A FOUR-FOLD EXPANSION DURING THE PAST YEAR

THE PHENOMENAL GROWTH OF FREYN ENGINEERING DERIVES FROM A THIRD OF A CENTURY OF DEPENDABLE PERFORMANCE

KOPPERS

METALLURGICAL PLANT DESIGN AND CONSTRUCTION

Freyn Engineering

DEPARTMENT OF KOPPERS COMPANY, INC.

109 NORTH WABASH AVENUE - CHICAGO 2, U.S.A. *Associated with* Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND; De Lattre & Frouard, Paris, FRANCE

For NORTHERN CRANES

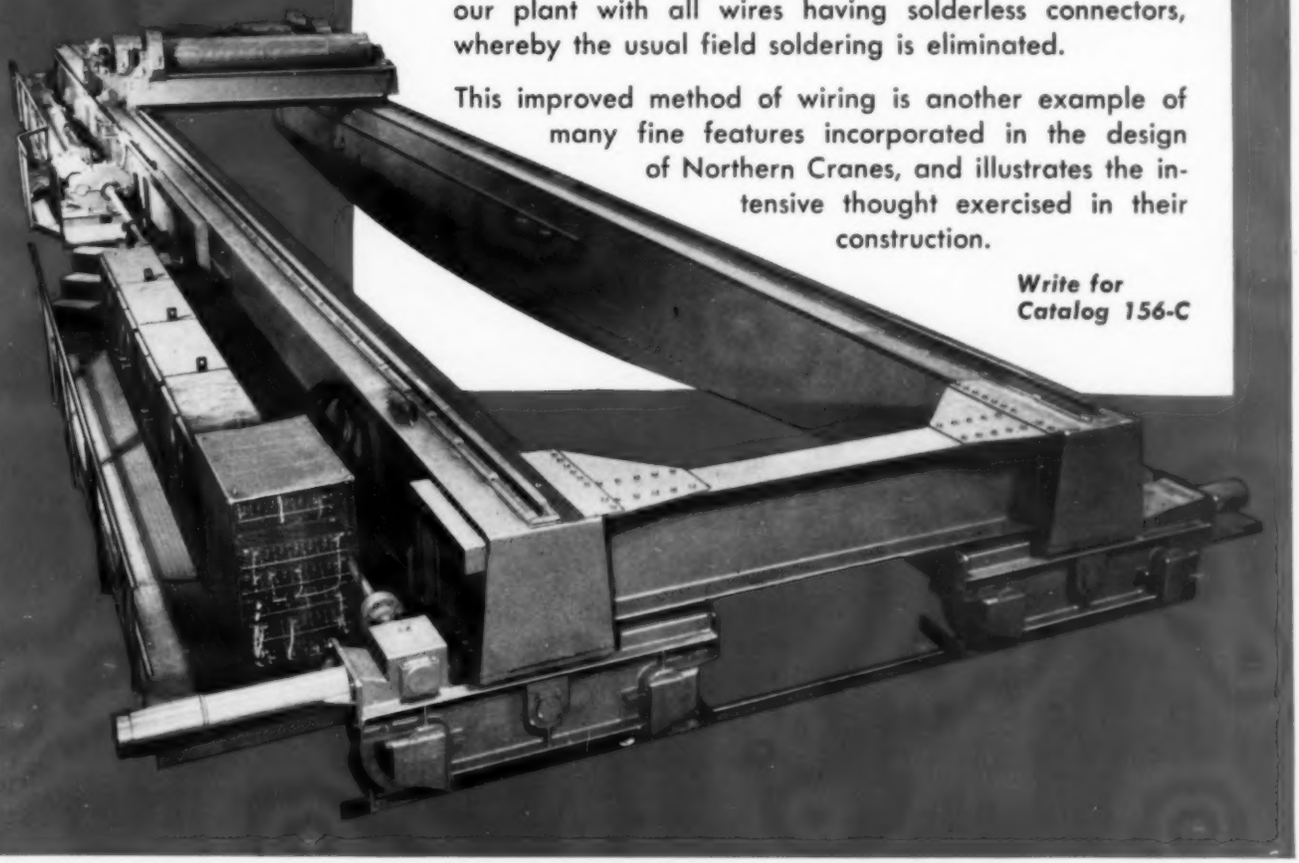
improved electrical layout

"Mounted on a Common Support"

For expedient field installation and wiring, all magnetic panels are mounted on a common support with all wires, where possible, contained in metal raceways having removable covers. Northern Cranes are completely wired in our plant with all wires having solderless connectors, whereby the usual field soldering is eliminated.

This improved method of wiring is another example of many fine features incorporated in the design of Northern Cranes, and illustrates the intensive thought exercised in their construction.

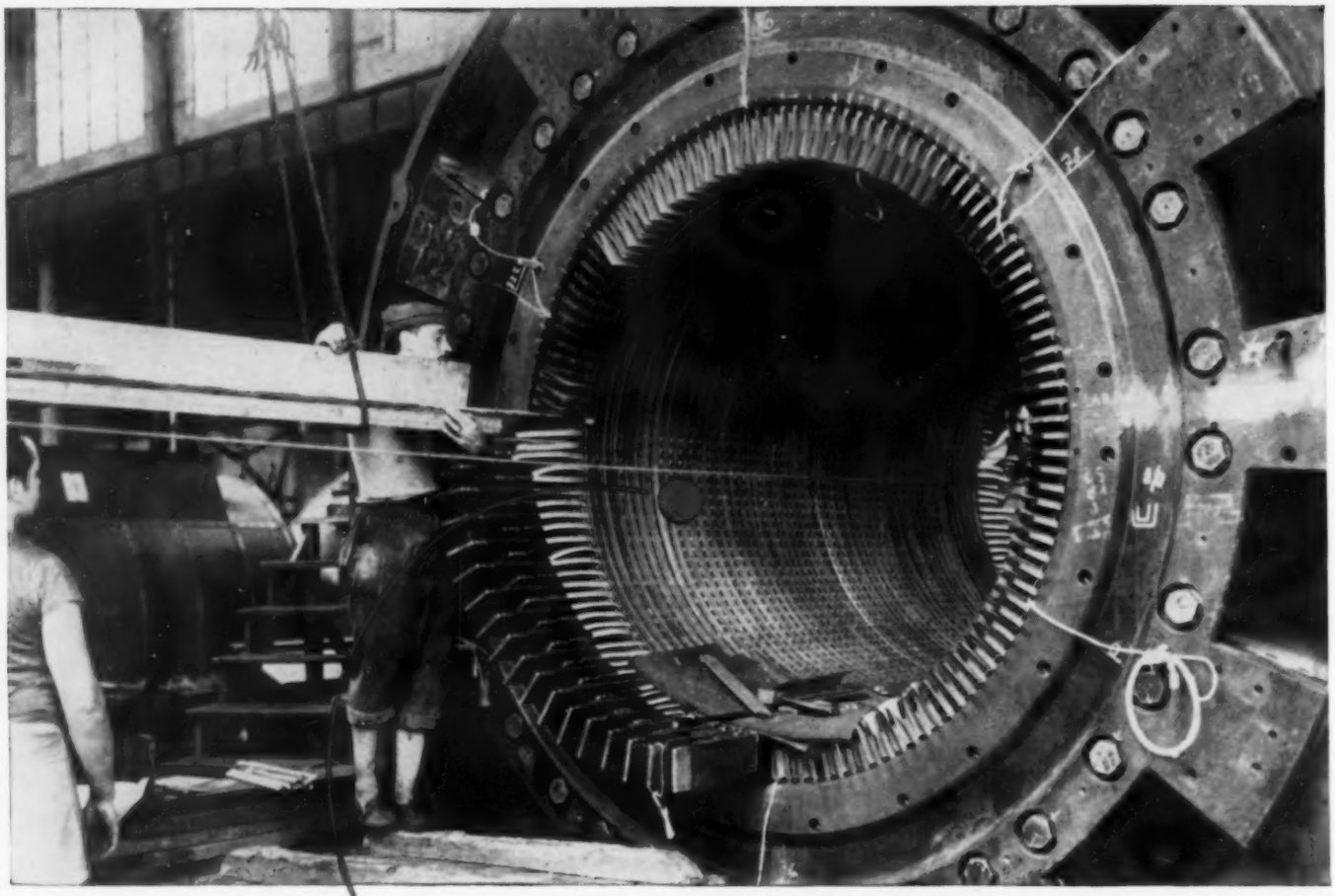
Write for Catalog 156-C



NORTHERN ENGINEERING WORKS

General Offices: 2615 Atwater St., Detroit 7, Michigan

BUILDERS OF CRANES AND HOISTS EXCLUSIVELY



National
gave this generator brand-new power

In the illustration at the top of the page the coil bars are being drawn into position. The lower illustration shows the coils being connected to the leads. This 3-phase, 50-cycle, 13,800-volt generator develops 45,000-kva at 1500-rpm.

Extra flexibility was needed in this rebuilding job. When the generator failed it was necessary to find someone who was equipped to handle the specialized repairs which were required. National was chosen. National engineers and technicians completely redesigned the stator windings; the National shops produced the bar design low-loss Roebel transposition type coils; and a National engineer was right there on the ground to supervise the actual rewinding of the generator. The result? A stator which gives more power at a lower operating temperature.

National can do the same for *your* motors or generators, whether they are special or not. Our experience and equipment are ready to work for you and to lower your power costs. Write or wire (or cable NATCOIL) *today*.

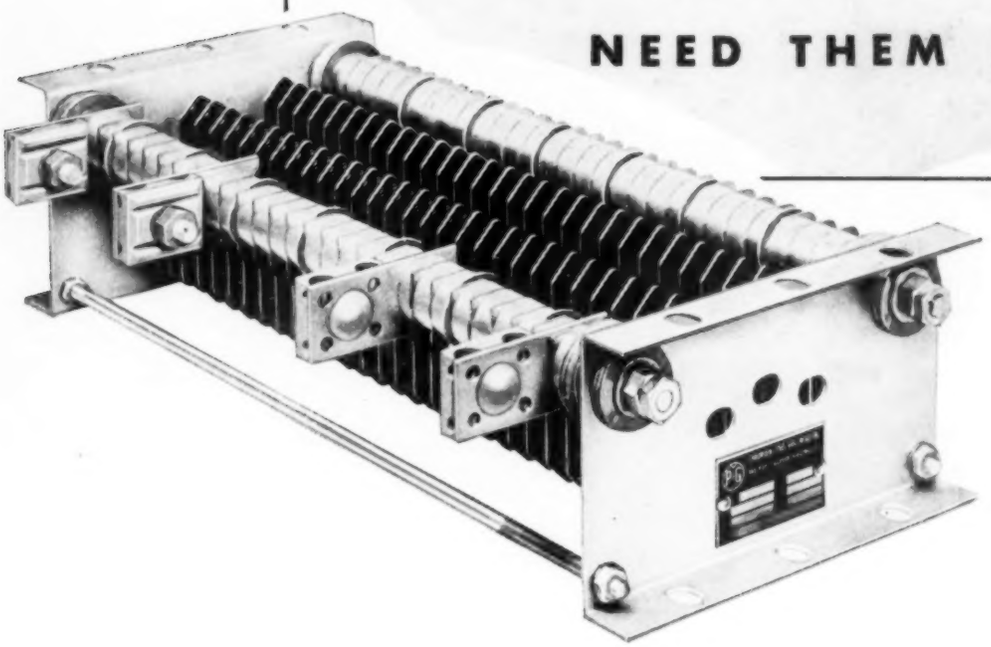
NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION— REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

E, I and R Values

WHERE AND WHEN You NEED THEM MOST



- ★ ALL STEEL CONSTRUCTION
- ★ MICA INSULATION
- ★ RUGGED TERMINALS
- ★ PROVISION FOR EXPANSION
- ★ ADEQUATE VENTILATION
- ★ UNAFFECTED BY VIBRATION
- ★ MOISTURE RESISTANT
- ★ CORROSION PROTECTED

Write for Bulletin No. 500

The resistance grids used for P-G STEEL GRID RESISTORS are produced in a wide variety of values, thus the current requirements for accurate motor control are readily obtained. These resistors, built of steel and mica, are able to withstand vibration, moisture or corrosive fumes, and maintain remarkably constant electrical values. Hence, they are the "Trouble Free" resistors with the longer service life. Try P-G on your next application.

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

For any kind of metallurgical construction

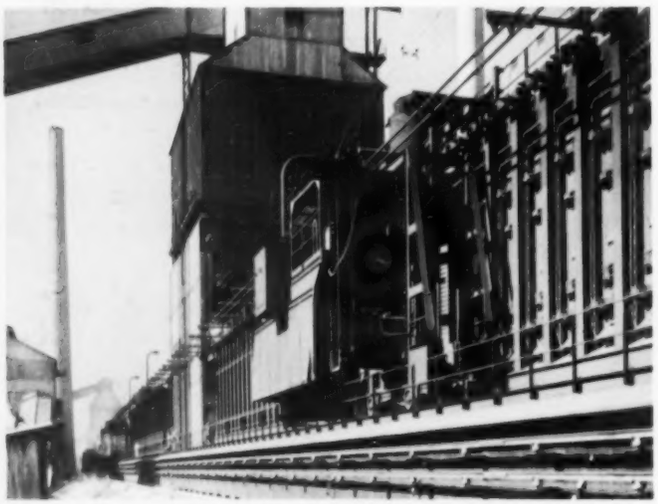
The installations pictured here give some indication of the scope of Koppers Metallurgical Engineering and Construction Services. Our Engineers and Management welcome the opportunity to consult with you.

ALL BRANCHES of the iron and steel industry *can count on Koppers* for comprehensive design, engineering and construction services, because Koppers Company is a specialist in the metallurgical field.

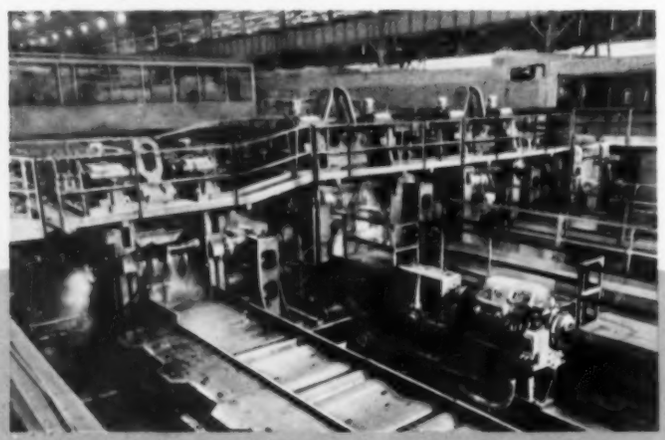
The Engineering and Construction Division of Koppers has long been recognized as a leader in the design and construction of coke-oven plants, auxiliaries and coal chemicals plants.

The Freyn Engineering Department of this Division specializes in the design and construction of blast furnaces, open-hearth furnaces and sintering plants . . . in the engineering of mills, power plants and other steel plant facilities.

Freyn-Designed and Constructed Sintering Plant. The sintering process permits *maximum* utilization of iron-ore fines and blast-furnace flue dust; also, it increases the pig-iron production of existing furnaces.



These 106 new Koppers-Becker Underjet Coke Ovens carbonize approximately 2,600 net tons of coal per day. Built in two batteries, they are equipped with Waste-Gas Recirculation and Blast-Furnace Gas Underfiring Equipment.



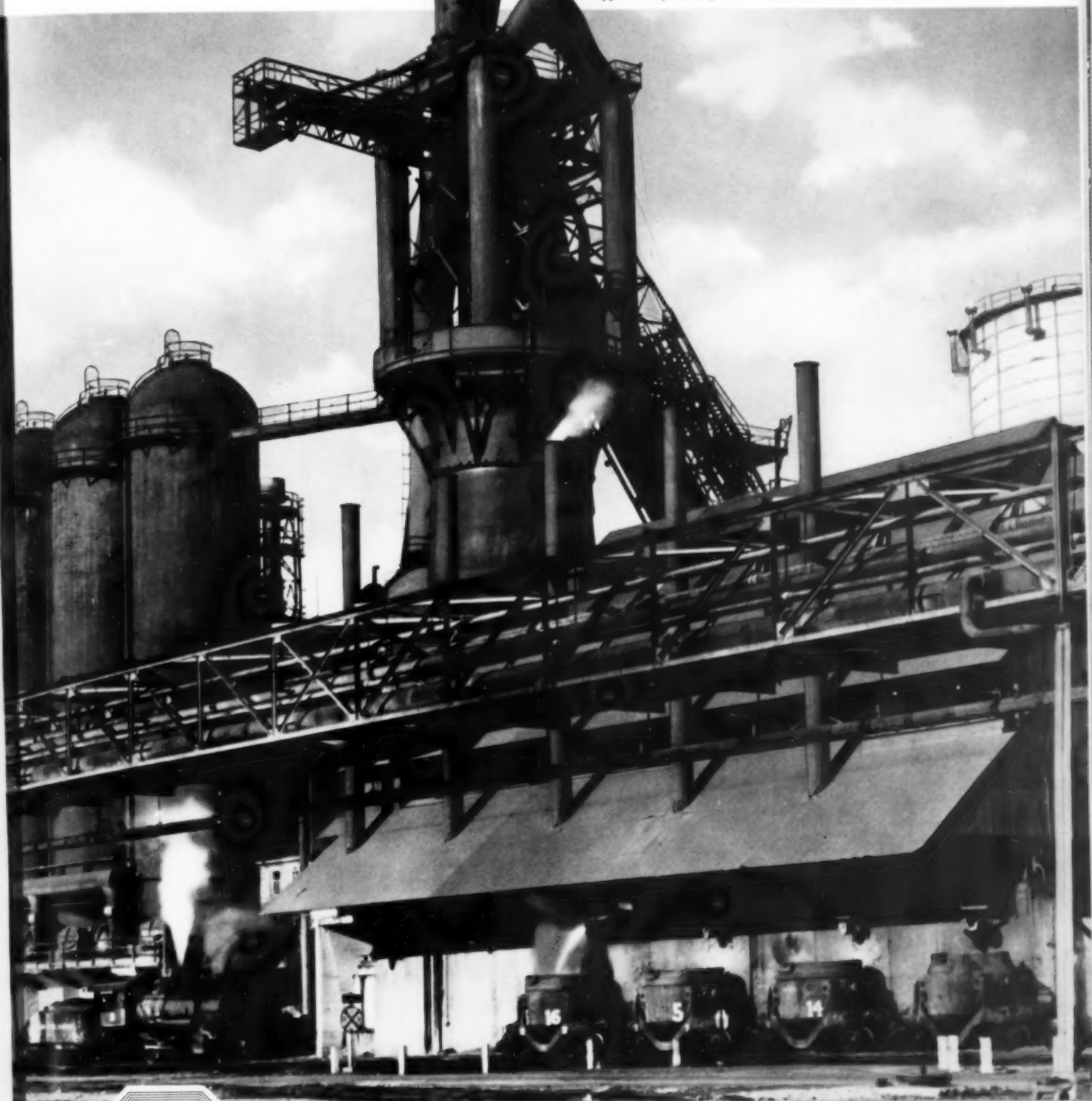
Freyn-Designed Structural Mill and Traveling Tilting Tables.

Freyn-Designed and Constructed Open-Hearth Furnaces.

This plant was constructed by Koppers for the recovery of ammonium sulphate, tar, light oil and pure benzol products from the carbonizing of 1,050 tons of coal daily.

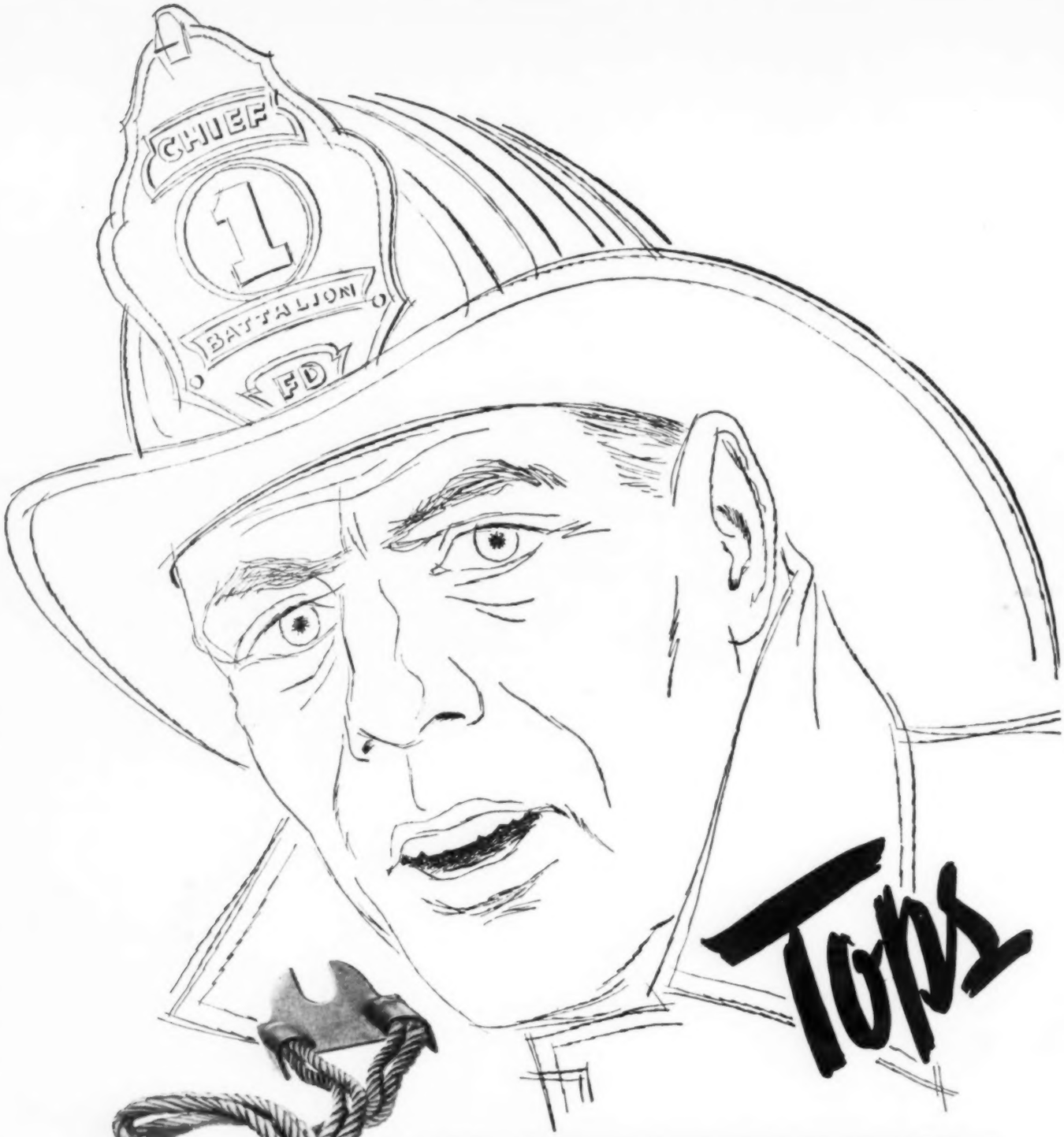
YOU CAN COUNT ON KOPPERS!

Typical Freyn-Designed and Constructed Blast Furnaces and Stoves.



KOPPERS *Engineering and Construction Division*

KOPPERS COMPANY, INC., PITTSBURGH 19, PA.



Tops

LIKE SPEER MULTIFLEX BRUSHES

For less sparking and burning

U.S. PAT. 2,181,076

SPEER Carbon CO.

ST. MARYS, PENNSYLVANIA

Subsidiaries

Speer Resistor Corp. – International Graphite & Electrode Corp.
Jeffers Electronics, Inc.

7587

What do you expect of an extreme pressure lubricant?
? high lubricating value
? good water separation
? rust preventive properties
? nonfoaming—noncorrosive
? greater stability
? tenacious

You'll get them all with GULF E.P. LUBRICANTS

All the desirable properties of extreme pressure lubricants are combined in Gulf E. P. Lubricants to insure longer gear and bearing life, and lower maintenance costs for steel mill gear drives.

Gulf E. P. Lubricants are specially compounded to withstand the shock loads and high pressures encountered in the toughest service. And they are outstanding in their ability to separate from water. When the proper grade is used and good maintenance practice is employed, lubrication difficulties caused by water can be minimized.

Other advantages: nonfoaming—saves loss of lubricant and mopping up; tenacious—minimizes channeling and throwoff; extremely stable for this type of lubricant; help prevent rust; and they are just as suitable for the lubrication of all types of bearings.

Gulf E. P. Lubricants are available in the proper viscosity for every gear requirement, ranging from 55 to 1050 S.U.V. at 210°F. For specific recommendations for your equipment, call in a Gulf Lubrication Engineer today. Write, wire, or phone your nearest Gulf office, or send the coupon below.

FIFTY YEARS OF SERVICE
1901 GULF 1951
PETROLEUM AND ITS PRODUCTS

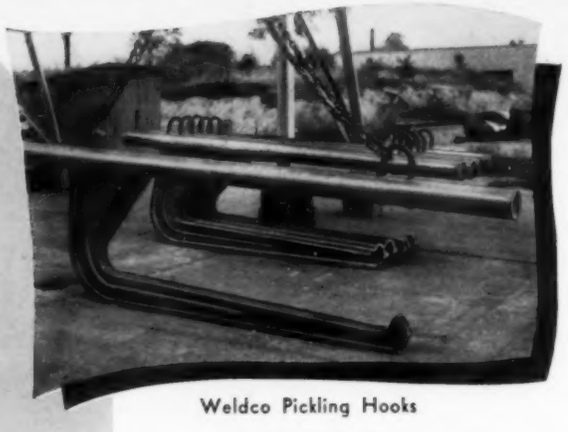
Gulf Oil Corporation · Gulf Refining Company I&SE
719 Gulf Building, Pittsburgh 30, Pa.

Please send me, without obligation, a copy of your pamphlet "Gulf E. P. Lubricants for Rolling Mill Gears and Pinions."

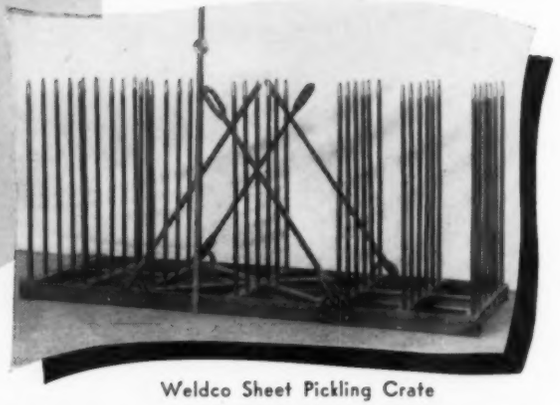
Name.....
Company.....
Title.....
Address.....

WHAT'S YOUR PICKLING PROBLEM

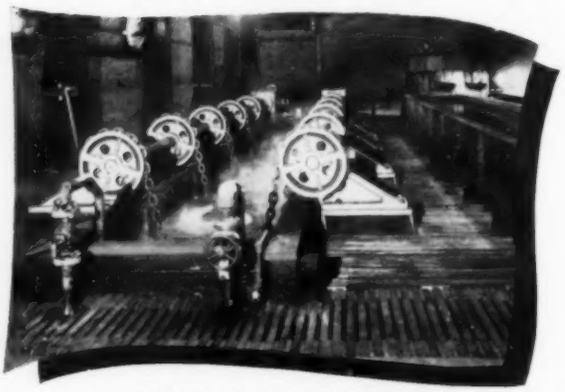
WELDCO SPECIALISTS HAVE THE ANSWER!



Weldco Pickling Hooks



Weldco Sheet Pickling Crate



Weldco Mechanical Bar Pickler

Weldco Mechanical Coil Pickler

IN HUNDREDS of plants, you'll find Weldco equipment all along the pickling line. For Weldco products are made of corrosion-resisting, hot rolled metals, which withstand attack from hot acids and other pickling solutions. They are strong yet lightweight, wear-resistant, durable, and long-lasting. You get all these advantages when you specify Weldco hooks, mechanical picklers, crates, baskets, racks, chain, steam jets, and accessories.

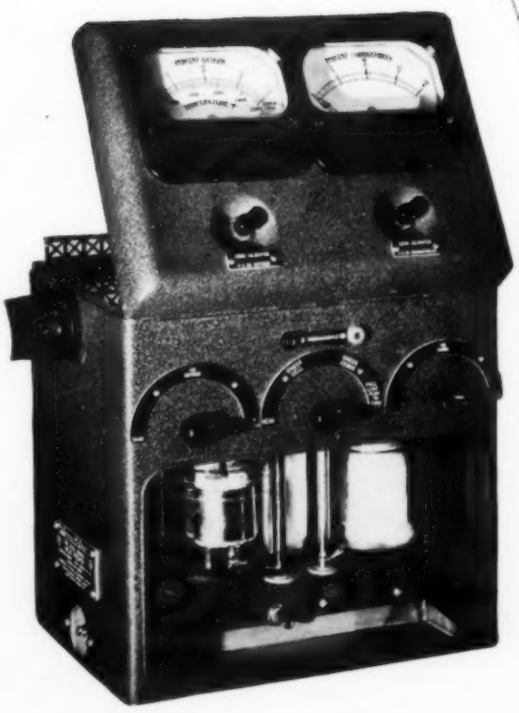
Weldco offers a complete, well-designed line of pickling equipment . . . plus the services of our experienced staff. Let Weldco engineers take care of all your pickling needs. For any problem, large or small, they have the practical, cost-cutting answer.

Weldco Monel Chain

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3720 OAKWOOD AVE. • YOUNGSTOWN 9, OHIO

Mobilizing BTU's



Now that the "heat's on" for record production, the calls are increasing for the services of the Cities Service Heat Prover. This scientific instrument gives an accurate, instantaneous and continuous picture of combustion conditions in all types of furnaces.

You'll readily be able to calculate any oxygen excess, waste combustible matter, and potential fuel savings. The results are like an accurate "diagram" of corrective measures needed to conserve heat units for consistently higher production at lower cost.

You'll see profit in applying the Cities Service Heat Prover . . . *not an instrument you buy, but a service we supply!* Call or write your local Cities Service office about arrangements. Or simply return the coupon today.

THE COMPLETE CITIES SERVICE LINE FOR THE METAL FABRICATING INDUSTRY INCLUDES

Chillo Cutting Oils • Trojan Greases • Trojan Gear Oils
Pacemaker T Hydraulic Oils • Optimus Cylinder Oils
Q-T (Quenching and Tempering) Oils

CITIES SERVICE OIL CO.
Sixty Wall Tower, Room 117
New York 5, N. Y.

Without obligation please send your booklet, "Combustion Control for Industry."

Name_____
Company_____
Address_____
City and State_____

CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

NEW

SHELL INDUSTRIAL

bring greater
under extreme

FOR GEARS...

SHELL MACOMA OILS

FOR ENCLOSED GEARS, Shell Macoma Oils solve the problem of extreme pressure lubrication with *seven distinct advantages:*

1. Extreme load carrying capacity . . . remarkable ability to prevent wear and seizure . . . even after long periods under heavy load.

2. Long-lasting oxidation stability . . . plus freedom from sludge formation in the presence of water.

3. Outstanding adhesion . . . maximum protection against rust, and against leakage through worn bearings and seals.

4. Non-corrosive . . . will not cause corrosion of steel or alloy bearings.

5. Non-Foaming . . . Shell Macoma Oils successfully overcome the tendency to foam caused by aeration of oil in the gear chamber.

6. Speedy water separation.

7. Complete stability in storage and in service . . . no tendency to separate, even in extremes of heat and cold.

SHELL

Be sure to get all the facts about these new Shell Macoma Oils. Check the coupon and attach to your letterhead for full information.

Two great new products of SH

EP LUBRICANTS

safety to gears and bearings loads and adverse conditions

FOR BEARINGS...

SHELL ALVANIA EP GREASE

FOR GREASE-LUBRICATED bearings, Shell Alvania Grease . . . the one grease that serves *all* grease applications in the majority of plants . . . *now is available with EP qualities added! . . . now even more Multi-Purpose.*

All of these unique advantages of Alvania Grease are therefore available for the first time to operators of machines subject to extreme bearing pressures:

1. Higher mechanical stability than any conventional grease at operating temperatures.

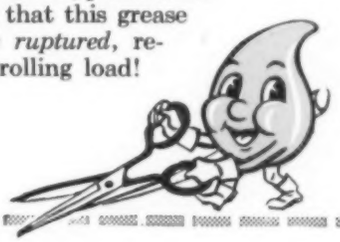
2. Pumpable at low temperatures . . . even through centralized lubrication systems.

3. Stable at high temperatures . . . no phase changes—still a grease at high temperatures—still a grease upon cooling.

4. Resistant to water . . . won't wash out.

5. Longer service life . . . reduced consumption.

Shell Alvania EP Grease is the answer to some of the toughest lubricating problems in industry. In rolling operations, for example, operators of steel, rubber, plastic and paper mills report that this grease film *just won't be ruptured*, regardless of shock rolling load!



Check the coupon and mail today for additional information about Shell Alvania EP Grease.

Shell Oil Company
50 West 50th Street, New York 20, N. Y.;
or 100 Bush Street, San Francisco 6, Cal.

Please send available data on

☐ Shell Macoma Oils ☐ Shell Alvania EP Grease

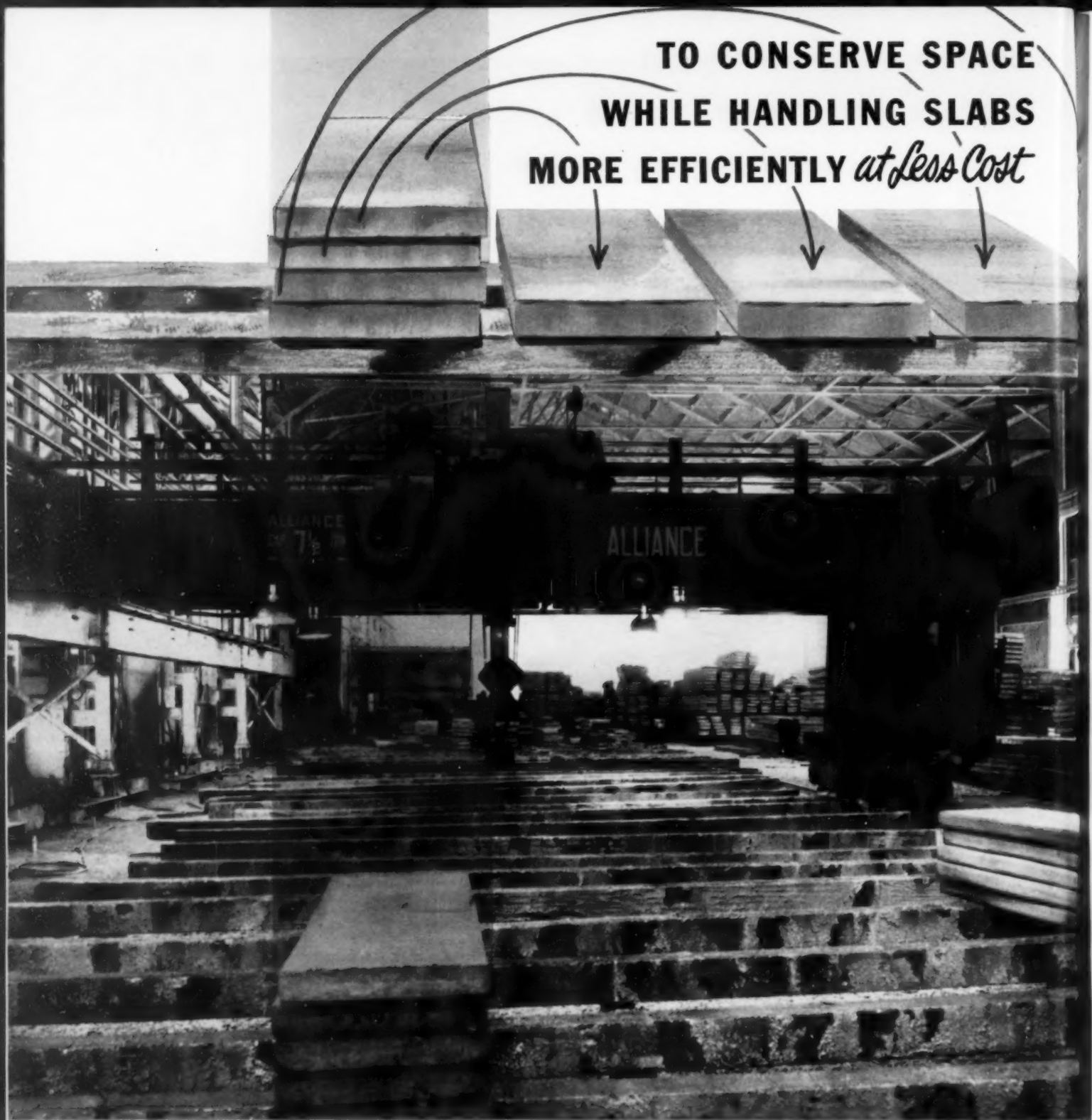
Name_____

Company_____

Title_____

Address_____

SHELL OIL COMPANY



Alan Wood Steel Company uses *Alliance* telescopic crane

Alliance

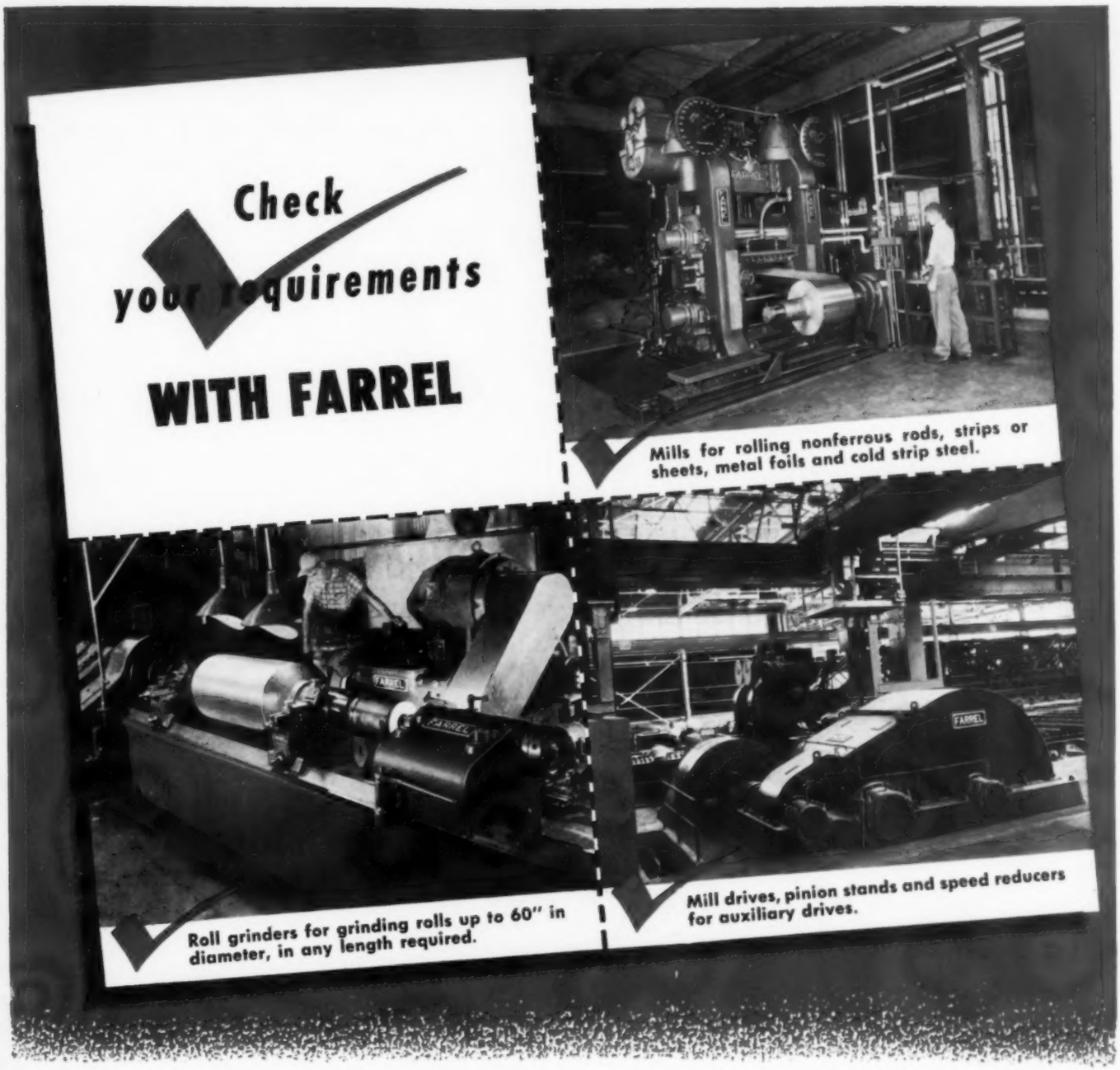
LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS
SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET
CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES
SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

THE ALLIANCE MACHINE COMPANY
Main Office, Alliance, Ohio ★ Pittsburgh Office, 1622 Oliver Building

● Operating underneath the main overhead crane, this newly developed, stiff-leg, semi-gantry, 7½ ton Alliance Slab Handling Crane services the slab storage area of the building as it turns and positions heavy slabs on the scarfing bed.

A minimum of headroom is required as this Alliance crane utilizes a special telescopic ram rather than a rack type ram to conserve overhead space. And, because of the compact design, this type crane can be installed where the rack type could not because it requires more headroom. The operator is located on the gantry leg level with his work for perfect visibility.

Alliance, with more than a half-century of crane building experience behind them, is continually developing new ways to give industry added lifting power at reduced costs. Call in your Alliance engineer today for a frank discussion of your heavy material handling problems. Be prepared now and tomorrow.


Check your requirements
WITH FARREL
Mills for rolling nonferrous rods, strips or sheets, metal foils and cold strip steel.
Roll grinders for grinding rolls up to 60" in diameter, in any length required.
Mill drives, pinion stands and speed reducers for auxiliary drives.

For close to a century, Farrel has specialized in designing rolling mill equipment for the solution of specific production problems.

Mills are built in a wide range of types and sizes for rolling nonferrous rods, strips or sheets, metal foils and cold strip steel. The company also designs and manufactures the reduction gear drives and pinion stands, coilers and special handling equipment required to make each installation a complete production unit.

Speed reducers for auxiliary drives are available in a wide range of ratios and capacities. Designs include single, double and multiple reduction units; speed-change units; right-angle drives and drives to meet special requirements.

Another problem solver is the Farrel roll grinder. Available in two types and nine standard sizes, these machines enable you to fix and maintain definite standards of accuracy and finish. Rolls are produced with a perfect surface, free from marks of any kind, ground straight, or with concave or convex contours of exact symmetry and accuracy.

Information and engineering consultation regarding any of the products mentioned on this page are available, without obligation.

FARREL-BIRMINGHAM COMPANY, INC. • ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.

Sales Offices: Ansonia, Buffalo, New York, Akron, Pittsburgh, Chicago, Los Angeles, Houston

Farrel-Birmingham®

FB-700

We're helping break up this

VICIOUS CIRCLE

THE more steel America produces the more machines are made—that means we need more gasoline, fuel oils and lubricants to operate the machines—so we need more steel to drill wells and to build pipe lines and refineries to provide the petroleum products to keep the machines running. It becomes a vicious circle—but we're helping break it up.

McKee Company's Iron and Steel Division is assisting materially in increasing iron and steel producing capacity—and thereby petroleum producing and refining capacity. McKee has in process of design, engineering and construction 6 Blast Furnaces, 2 Integrated Steel Plants, 1 Open Hearth Plant, 6 Major Petroleum Refinery projects and some 50 miscellaneous projects.

McKee's combined, world-wide experience and broad services to these two basic industries—steel and oil—continue to prove advantageous to both.

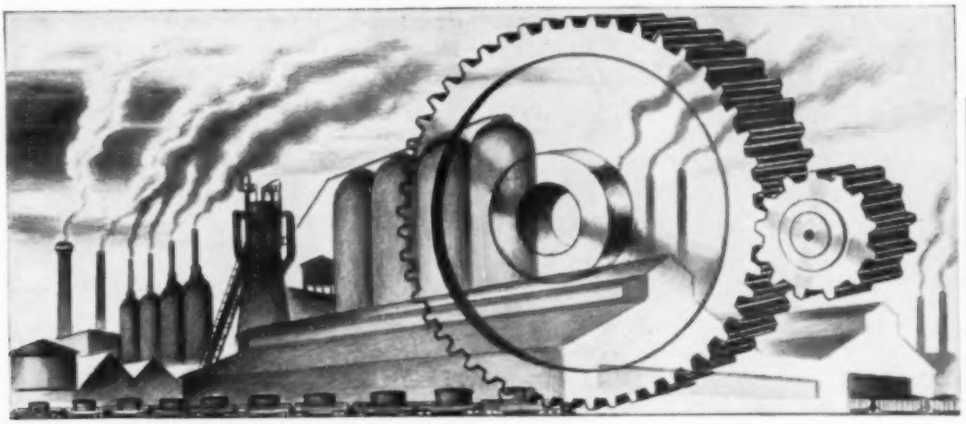
DESIGN, ENGINEERING AND CONSTRUCTION FOR THE IRON AND STEEL AND PETROLEUM REFINING INDUSTRIES

McKee *Engineering*

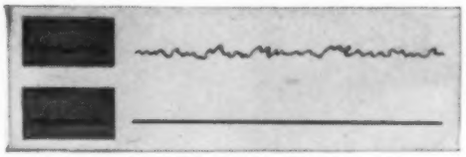
Arthur G. McKee & Company • Established 1905

Headquarters: McKee Building, 2300 Chester Avenue, Cleveland 1, Ohio. *New York:* 30 Rockefeller Plaza, New York 20, N.Y. *Tulsa:* 918 First National Bank Building, Tulsa 3, Okla. *England:* The Iron and Steel Division of Arthur G. McKee & Company, is represented by Head, Wrightson & Co., Ltd.

IT TOOK A LARGE STEEL PLANT to tell us how GOOD LEADOLENE *Klingfast* really is!

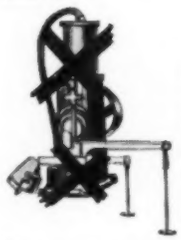


For many years it has been customary to use the Timken test machine to determine the breakdown point of lubrication. Recently a large steel plant decided that this was not a sufficient test to determine the safety point and went a step further as described in the text of this advertisement.



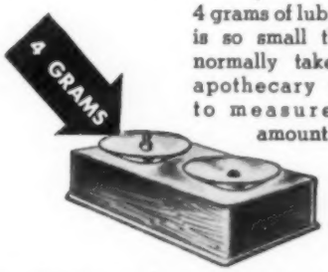
Normally the hardened and ground steel block and cup shown at the left is under constant lubrication during the Timken test and is fairly indicative of true operating conditions for bearings. However, this is not true for the lubrication of open gears. In the latter instance the applications are always of intermittent nature with the result that the application or film applied has to serve a rather long period of time before renewal is made.

This condition also exists with sleeve bearings where applications were intermittent, the bearings usually being of babbitt, bronze and cast iron.



To accomplish this condition on the Timken testing machine, the pump or flow of oil was shut off and an application of 4 grams of lubricant placed on a cup and block.

The machine was then set in operation and was watched closely until the block began to show signs of scoring as illustrated in the top line of the chart. So long as a project line appeared as is shown in the lower half of the chart, the lubricant was performing satisfactorily. In conducting this test no unusual methods were used . . . 4 grams of the lubricant under test were applied to the exterior surface of the block and cup—at room temperature. To our knowledge and to the steel company who made this original test, it is the only method that is a satisfactory answer to the lubrication of open gears in service—a lubricant that will stay on the gears and lubricate for the greatest length of time without failure.



4 grams of lubricant is so small that it normally takes an apothecary scale to measure the amount.

At the right we show the actual laboratory results of the comparative 4 gram test with competitive products.

The lubricants tested in comparison to Klingfast are all considered of quality nature and are used for open gear lubrication in general industry but particularly so in the severe service of steel plants.

Because open gears are lubricated periodically and not constantly, the pH-ilm must have lasting or enduring characteristics. Thus, the 4 gram test is truly representative of actual field operation tests for open gears. This enduring action together with extremely high pH-ilm strength guarantee the machine actual lubrication and protection.

We will gladly send you a generous sample on request.

RESULTS OF 4 GRAM *Klingfast* LEADOLENE TEST

30 MINUTES
without scoring or failing.

LUBRICANT "A"

5 MINUTES
A high grade compound scored at 5 minutes and failed in 12 minutes.

LUBRICANT "B"

8 MINUTES
A reputable lubricant of residual nature scored and failed in 8 minutes.

LUBRICANT "C"

6 MINUTES
A good lead compounded extreme pressure grease lubricant for open gears and general grease lubricant scored and failed in 6 minutes.

LUBRICANT "D"

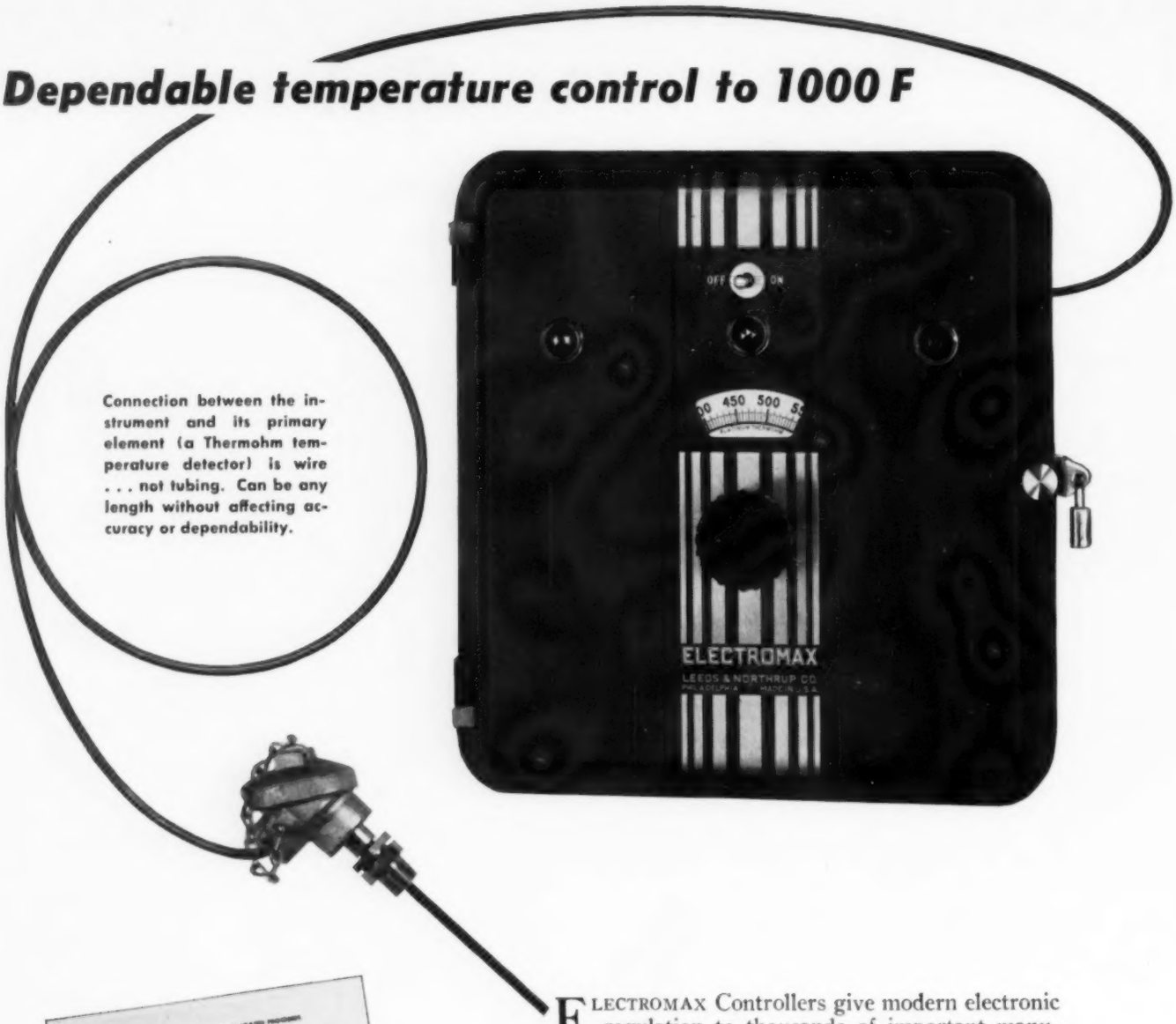
6 MINUTES
A well-known lead compounded pressure grease lubricant for open gears and pressure lubricating systems scored and failed in 6 minutes.

*LEADOLENE—the "I. P. Lubricant" (Indestructible pH-ilm) . . . for industrial needs.

The Brooks Oil Co.

Pittsburgh 12, Pennsylvania
Cleveland, Ohio
Hamilton, Ontario
Warehouses: In Principal Industrial Cities

Dependable temperature control to 1000 F



Connection between the instrument and its primary element (a Thermohm temperature detector) is wire . . . not tubing. Can be any length without affecting accuracy or dependability.

Typical samples of the information available on Electromax Control. Specify nature of process and whether fuel is gas, oil, steam or electricity.

ELECTROMAX Controllers give modern electronic regulation to thousands of important manufacturing processes. In any application up to 1000 F they exactly fill the bill for non-recording controllers of outstanding dependability.

Electromax has the sensitivity, accuracy and dependability of its big brother Speedomax Recording Controller. Likewise, it is not affected by vibration or building tremors . . . can even be mounted on the frame of a molding press. The instrument needs almost no attention, because it has only one moving part . . . a covered plug-in type relay. There's usually no need to open the instrument door for months at a time.

Electromax Control is available to provide any one of three control actions. For the more simple process requirements, on-off or two position control is usually used. For processes requiring control within unusually close limits, two different types of proportional control are available . . . Position-Adjusting Type and Duration-Adjusting Type. All three types of control action can be applied to electric, steam or fuel heating.

For further information, write our nearest office, or 4942 Stenton Ave., Phila. 44, Penna.

MEASURING INSTRUMENTS TELEMETERS AUTOMATIC CONTROLS HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl Ad ND47(2)

MOBILIZE YOUR PLANT

for maximum production now!

YALE
4,000 LB. CAPACITY
ELECTRIC TRUCK

Get the most from every machine ...every hour...every dollar with

YALE INDUSTRIAL TRUCKS

HERE are gas and electric trucks that will help gear your plant for *all-out* efficiency!

These Yale fork lift trucks stack materials nearly 16′ high... put wasted aisle and overhead space to work... relieve workers from costly, slow, back-breaking hand lifting.

They stay on the job, too... keep production lines well fed and shipments rolling. For example, the Yale electric truck with magnetic contactor controls cuts "down time" to a minimum. The Yale gas truck with fluid drive greatly increases clutch life and reduces maintenance costs. And these are only two Yale exclusives—there are many others!

Let Yale help you mobilize your plant for *greater production at lower unit costs* right now! Send coupon today for all the facts.

SEND THIS
COUPON TODAY

THE YALE & TOWNE MFG. CO.
Department 349
Roosevelt Boulevard & Haldeman Ave., Philadelphia 15, Pa.

☐ *Please have your local representative call on me.*
☐ *Please send me, free, the "How Book of Cost Cutting Material Handling."*

Name_____

Company_____

Street_____

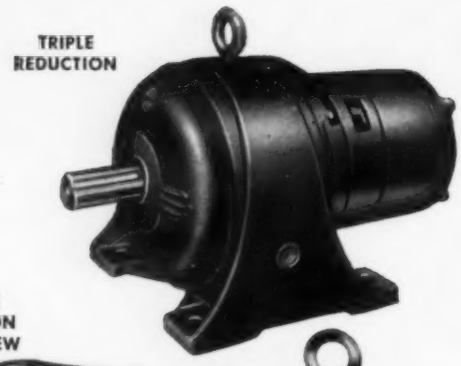
City_____ State_____

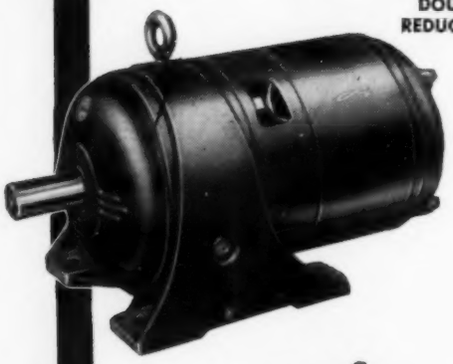
YALE & TOWNE

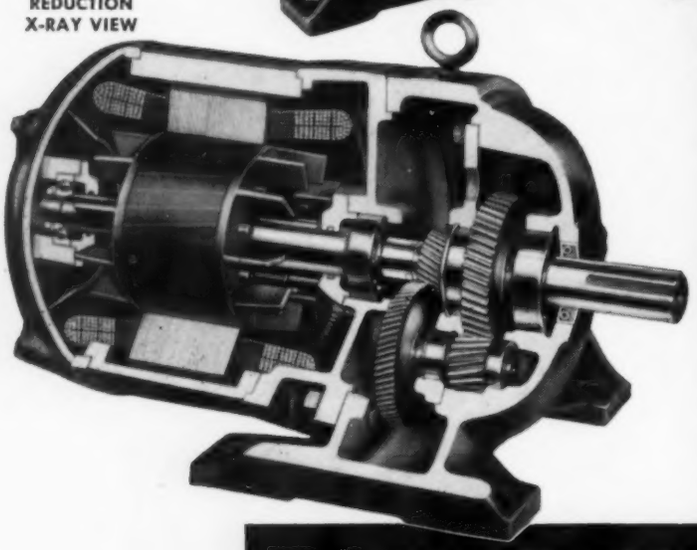
The Yale & Towne Manufacturing Co., Philadelphia 15, Pa.

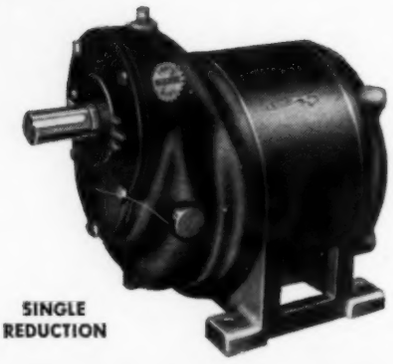
Yale is the registered trademark of the Yale & Towne Manufacturing Co.

In Canada write The Yale & Towne Manufacturing Company, St. Catharines, Ontario









FOOTE BROS.-LOUIS ALLIS GEARMOTORS

PROMPT DELIVERY!

Would prompt delivery of Gearmotors solve your problem?

If you're up against costly delay, then keep in mind that you can count on prompt delivery of Foote Bros.-Louis Allis Gearmotors.

Foote Bros. offer the finest Gearmotor obtainable. A Gearmotor of superior design and construction—produced jointly by Foote Bros. and Louis Allis—both leaders in their respective fields.

Foote Bros.-Louis Allis Gearmotors are available in single, double and triple reductions to provide output speeds of 780 down to 7.5 r.p.m. Capacities from 1 h.p. through 150 h.p. Open drip-proof, splash-proof, enclosed and explosion-proof motors.

Mail the coupon for Bulletin GMA.

FOOTE BROS.
GEAR AND MACHINE CORPORATION
Dept. IAS, 4545 So. Western Blvd., Chicago 9, Ill.

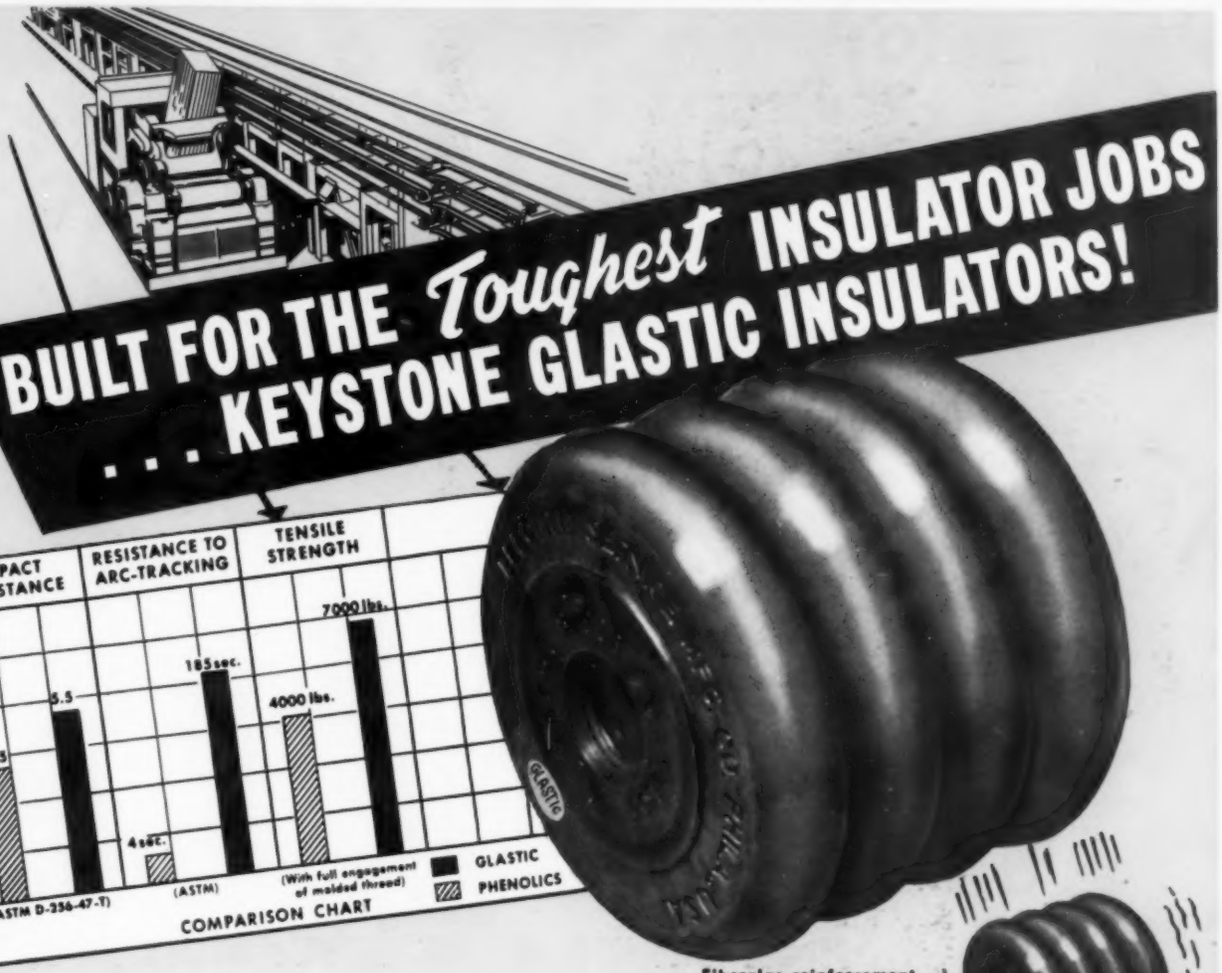
- **Duti-Rated Gears—file hard tooth surfaces—resilient cores.**
- **Tang driven motor shaft pinion positively positioned.**
- **Extra capacity ball or tapered roller bearings.**
- **Cast iron housing for maximum rigidity under load. Large oil reservoir, splash lubrication.**
- **Leakproof oil seals.**
- **Dynamically balanced die-cast aluminum rotor. Impregnated windings assure protection from moisture, dust, and oil.**
- **Ball bearing motor for trouble-free operation.**

FOOTE BROS.
Better Power Transmission Through Better Gears

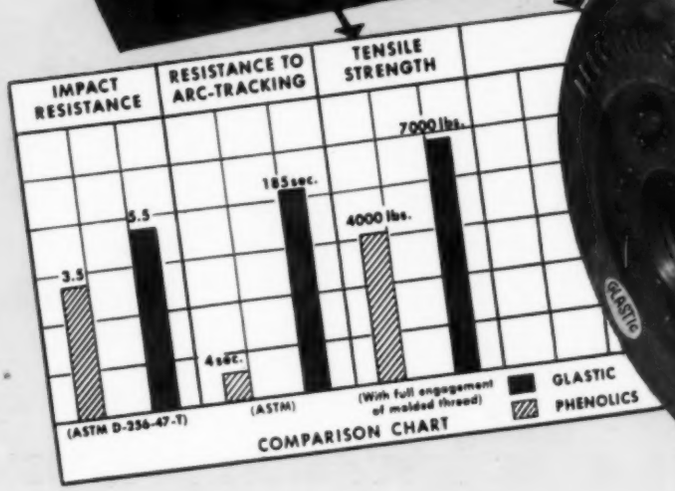
Write for Bulletin GMA

Foote Bros. Gear and Machine Corporation
Dept. IAS, 4545 So. Western Blvd.
Chicago 9, Ill.
Send me Bulletin GMA on
Foote Bros.-Louis Allis Gearmotors.

Name.....
Company.....
Position.....
Company Address.....
City.....*Zone*.....*State*.....



BUILT FOR THE *Toughest* INSULATOR JOBS . . . KEYSTONE GLASTIC INSULATORS!



Keystone Glastic insulators are specifically designed and made for hard service use. Where ordinary insulators become brittle and break down completely under high temperatures and current overloads, Keystone Glastic insulators are unaffected.

You get many superior advantages with Glastic insulators not found in those of phenolic composition. Keystone Glastic insulators resist high heat, chemicals, rough handling, salts and moisture.

Insulators are molded around completely machined inserts with tapped threads in blind holes, all zinc-plated finish for corrosion resistance. If you are looking for insulators with outstanding properties for tough service, investigate Keystone Glastic insulators. Can be designed to meet your immediate requirements.

The Glastic insulator is one of a complete Keystone line available for use with rail, wire or angle conductors, in either over-running or under-running operation.

Write today for new bulletin 609A on the Glastic Insulator. Address Dept. I.E. 1721.

Fiberglas reinforcement gives Glastic insulators exceptional strength for impact and shock resistance, dimensional stability and rigidity.

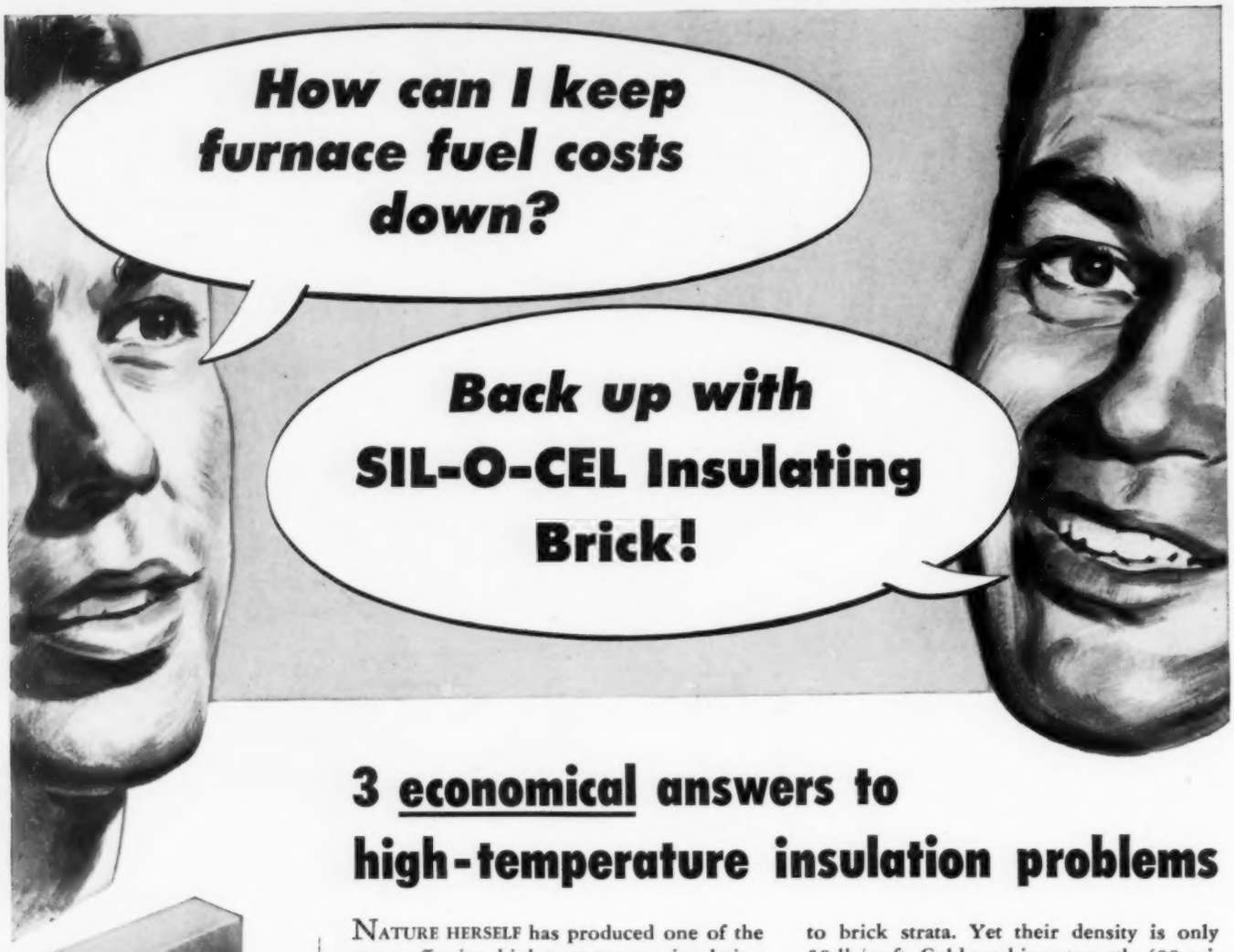
Exceptional resistance to arc-tracking . . . 45 times better than phenolics.

Non-absorbent. Resists chemicals, most acids, salts and hydrocarbons.

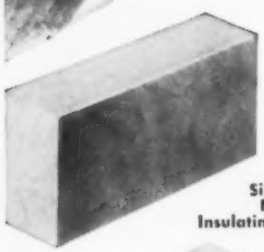
Suitable for operation under maximum sustained temperatures up to 300° F.

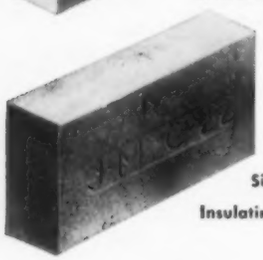
ELECTRIC SERVICE MANUFACTURING CO.

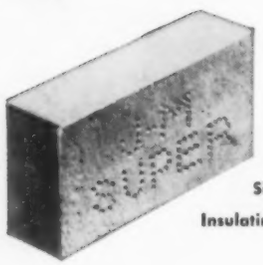
PHILADELPHIA 32, PENNA.



3 economical answers to high-temperature insulation problems


Sil-O-Cel Natural Insulating Brick


Sil-O-Cel C-22 Insulating Brick


Sil-O-Cel Super Insulating Brick

NATURE HERSELF has produced one of the most effective high-temperature insulating materials ever discovered—diatomaceous silica, from which Sil-O-Cel® Insulating Brick are made.

These insulating brick are used for back-up insulation behind fire brick or insulating fire brick linings in boilers, stills, stacks, heat-treating furnaces, kilns, lehrs, flues, retorts, and other types of high-temperature equipment.

Sil-O-Cel Insulating Brick have excellent insulating qualities combined with high load-bearing characteristics and light weight.

Made in all standard shapes of the 2½ in. and 3 in. series, Sil-O-Cel Insulating Brick are produced in three basic types:

SIL-O-CEL NATURAL INSULATING BRICK
for temperatures to 1600F

Quarried directly from one of the world's purest deposits of diatomaceous silica, these insulating brick have a conductivity of only 0.79 Btu in./sq ft/F/hr at 1000F mean temperature, with heat flow perpendicular to brick strata. Yet their density is only 30 lb/cu ft. Cold crushing strength, 400 psi.

SIL-O-CEL C-22 INSULATING BRICK
for temperatures to 2000F

Ideal where high load-bearing properties are needed, this type of Sil-O-Cel is calcined, and has a cold crushing strength of 700 psi. Conductivity is 1.88 Btu in./sq ft/F/hr at 1000F mean temperature. Density, 38 lb/cu ft.

SIL-O-CEL SUPER INSULATING BRICK
for temperatures to 2500F

A calcined insulating brick for unusually high temperatures. In many cases, it is also possible to save on construction costs by reducing the thickness of fire brick or insulating fire brick when backed with Sil-O-Cel Super Insulating Brick. Conductivity is 1.95 Btu in./sq ft/F/hr at 1000F mean temperature. Density, 40 lb./cu. ft. Cold crushing strength, 300 psi.

For further information, write to Johns-Manville, Box 290, New York, N. Y. In Canada, write 199 Bay St., Toronto 1, Ont.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville *first in* **INSULATIONS**

Boost Monthly Scarfing Tonnages...

clean Blooms, Slabs and Billets completely... *with*

AIRCO'S HEAVY DUTY SCARFING TORCHES

Airco Heavy Duty Scarfing Torches (Series 6000) speed up steel conditioning . . . help meet today's demands for more and more production by relieving billet and slab yard bottlenecks.

Instead of the usual 1" to 1½" cut, they will scarf a shallow path 2½" or wider with no greater oxygen consumption per square foot of scarfing than that of ordinary torches. Moreover, by reason of the shallowness and speed of the cut, less surface metal is removed. Depth of scarf can be controlled to within $\frac{1}{16}$ *of an inch.*

Actual production figures, based on the records of a number of mills, prove that scarfing tonnages are increased by the use of these torches. These figures will be still further increased when facilities are provided for more rapid handling of the steel.

Call your nearby Airco office today. They will be glad to give you information on a complete line of scarfing equipment.

AIRCO

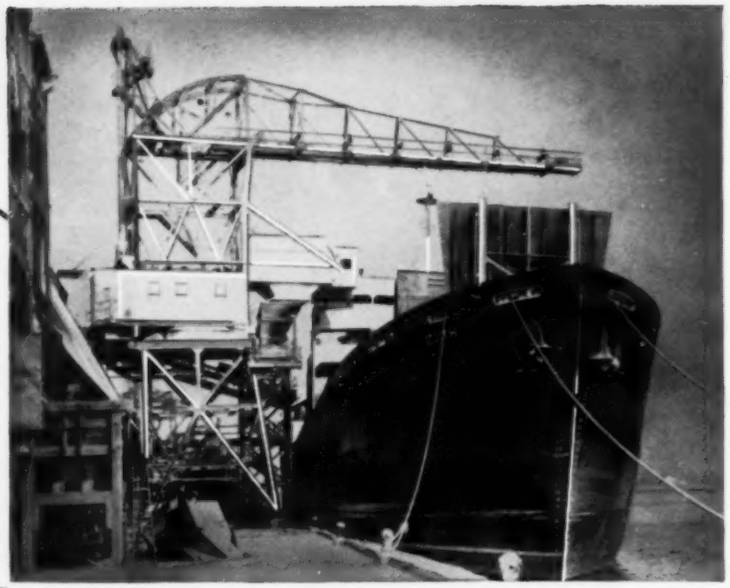
AIR REDUCTION

AIR REDUCTION SALES COMPANY • AIR REDUCTION MAGNOLIA COMPANY
AIR REDUCTION PACIFIC COMPANY
REPRESENTED INTERNATIONALLY BY AIRCO COMPANY INTERNATIONAL
Divisions of Air Reduction Company, Incorporated
Offices in Principal Cities

SHIP

TO SHORE

TO STORAGE



...600 GROSS TONS PER HOUR

The unloading tower and boom stacker, built by Derrick & Hoist Co., Inc., for a large New Jersey Plant, are just about the ultimate in modern, mechanized materials handling. The machines are a composite design of unloading tower and a revolving crane operating a large digging bucket, and a new type stacker with belt conveying and distributing equipment. The equipment handles 600 gross tons per hour . . . and heavy loads and brute punishment are "taken in stride" by SKF Pillow Blocks and Spherical Roller Bearings in the boom hoist and swinger, in the foot block of the stacker and in the conveyor drive.

Builders of all types of materials handling cranes for all industries rely on SKF. They recognize SKF dependability under all service conditions, SKF ability to supply the right bearing for the right place. 7259

8 REASONS WHY SKF IS PREFERRED BY ALL INDUSTRY

integrity
craftsmanship
metallurgy
tolerance control
surface finish
product uniformity
engineering service
field service

SKF

BALL AND ROLLER BEARINGS

* *For detailed information, write 24-16 Bridge Plaza, South, Long Island City 1, New York.*

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
—manufacturers of SKF *and* HESS-BRIGHT *bearings.*

. . . For all Cold Processing Operations

Cold rolling and cold processing rolls made by "Tool Steel" have proven that they give the desired finish at the **lowest cost per ton!**

"Tool Steel" manufactures both the homogeneous rolls for cold rolling and the case hardened "Tool Steel" Process rolls for other cold operations. Thus "Tool Steel" offers you **the proper roll for any cold operation.**

"Tool Steel's" heat treating "know-how" (since 1909) will produce for you the very best rolls for your service!

Let "Tool Steel's" Representatives and Engineers show you how you can save money by using "Tool Steel" Rolls.

"TOOL STEEL" PROCESS

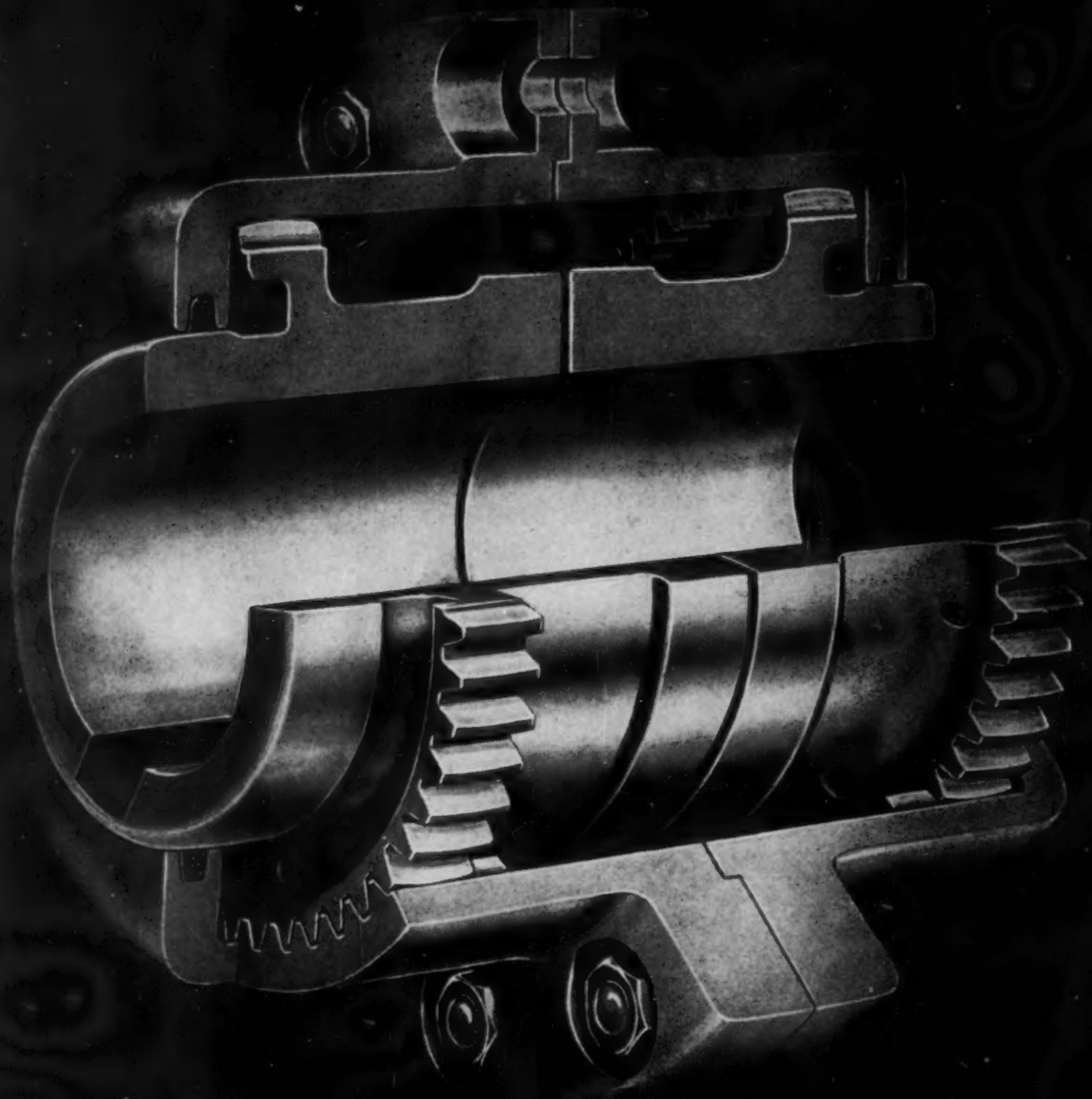
The Standard of Quality

for GEARS • PINIONS • SPROCKETS • WHEELS *and other* HARDENED PRODUCTS

THE TOOL STEEL GEAR & PINION CO.

CINCINNATI 16, OHIO, U. S. A.

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

FOR LESS SERVICING...
AND MORE SERVICE...
AROUND THE CLOCK...
YEAR-AFTER-YEAR...

SPECIFY

Pacific

Precision Built CENTRIFUGAL STEAM TURBO **PUMPS**

You Specify—The liquid to be pumped and the complete conditions of service.

Pacific Will Specify—The most efficient size, the proper type of pump for your service and the correct materials for the liquid.

You Will Receive from Pacific—A custom built pump with pressure castings, hydrostatic tested . . . each part precision finished and inspected . . . one-piece impellers, dynamically balanced . . . performance tested and shipped with parts protected with rust inhibitor. *Write for Bulletin Number 1.*

Pacific Pumps inc.
ONE OF THE DRESSER INDUSTRIES

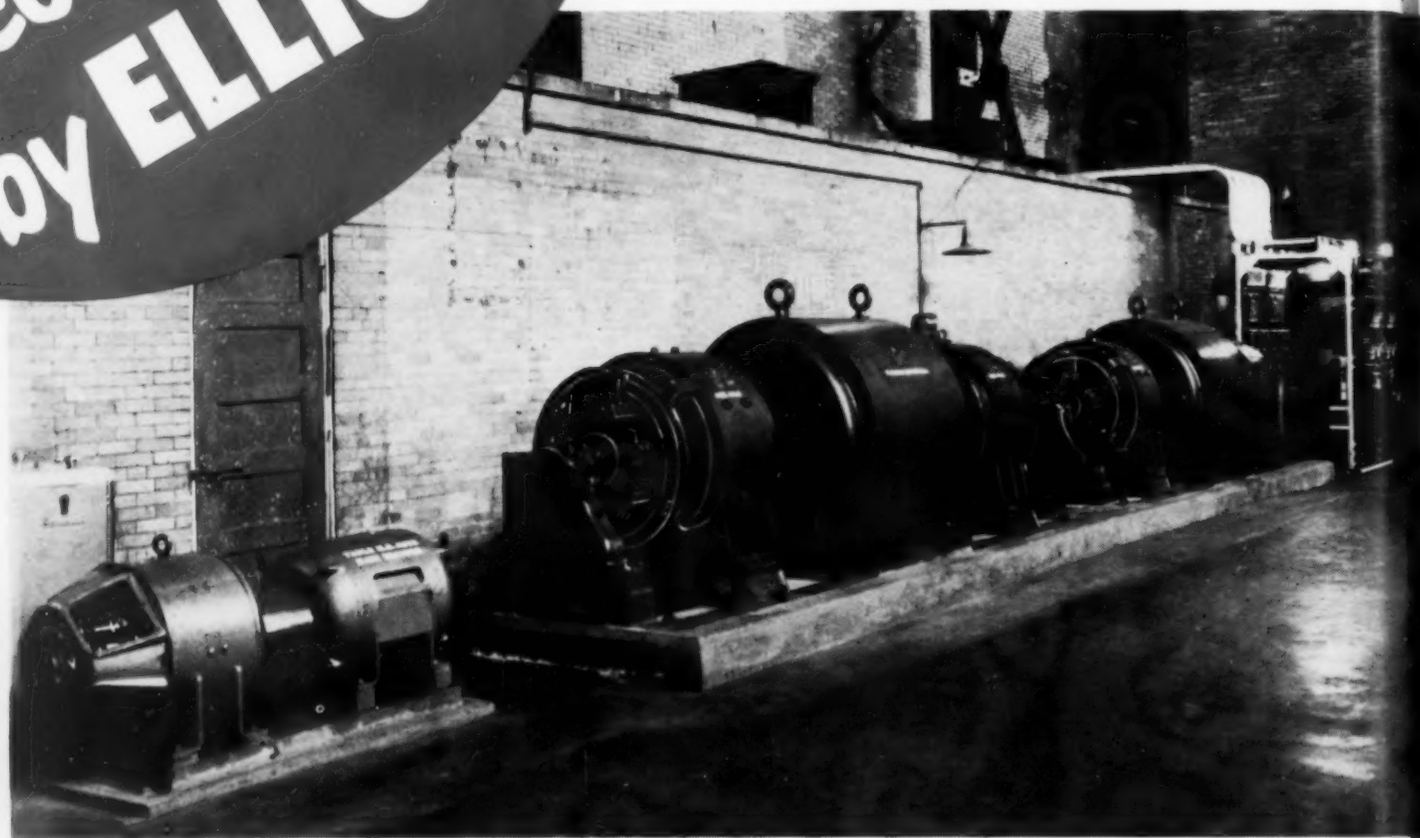
HUNTINGTON PARK, CALIFORNIA

Export Office: Chanin Bldg., 122 E. 42nd St., New York • *Offices in All Principal Cities*

X-2

Power conversion by ELLIOTT

Slabbing mill are



The two Elliott 400-kw motor-generator sets, each consisting of a 600-hp, 1480-rpm, 6600-volt, 25-cycle, squirrel cage induction motor driving two 200-kw, 250-volt dc generators which furnish variable voltage power to two W-618 Elliott Mill Motors such as shown on opposite page. Excitation motor-generator set at extreme left. Cutler-Hammer control at extreme right applied by Elliott for complete co-ordination.

...another Elliott

Here is another typical example of Elliott engineering co-ordination, quality craftsmanship, and rugged construction, combined to provide the utmost in reliable performance. Shown on these pages are Elliott generators and motors engineered to serve the front and rear tables of a 44" slabbing mill at the South Chicago Works of United States Steel Company . . . a service which is a true test of ruggedness, of reliability, and of adaptability to exacting service.

Elliott
FABRI-STEEL
MOTORS AND GENERATORS

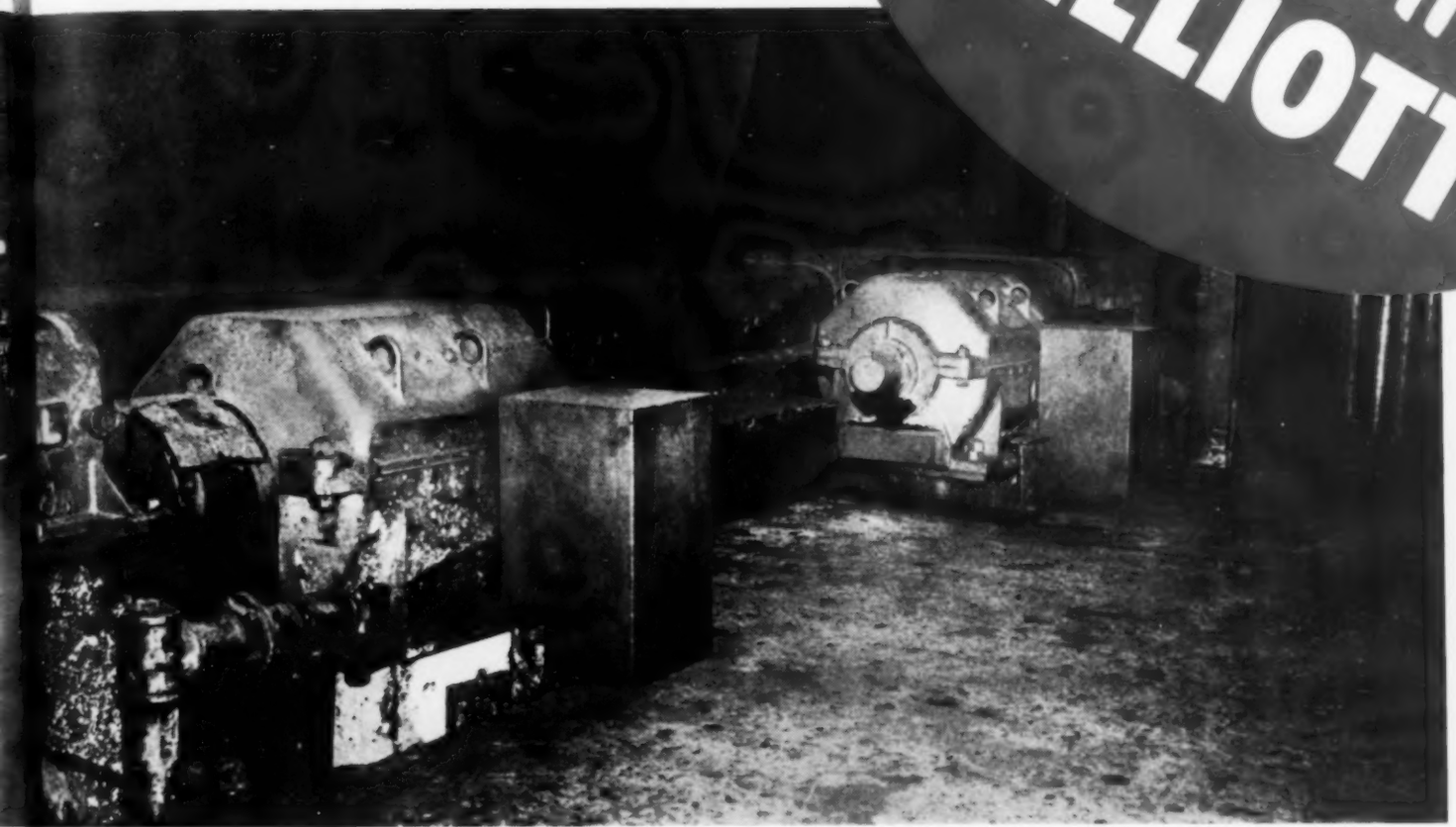
DEPT. 13
RIDGWAY DIVISION
RIDGWAY, PA.

ELLIOTT

PLANTS AT: JEANNETTE, PA. • RIDGWAY, PA. • AMPERE, N. J.
DISTRICT OFFICES IN

table drives a real test

Power application by ELLIOTT



Two of the four W-618, 200-hp Elliott Crocker-Wheeler Mill Motors which drive the roll tables. These motors are designed, with associated equipment, to accelerate the 24 rolls per table from standstill to rated motor speed in from 2 to 2.8 seconds.

job well done!

The heavy mill table application of the two motors in the photo above is an indication of the conditions under which they operate. They are Elliott Crocker-Wheeler Mill Motors — built to take the abuse of heavy overloads, reversing strains, heat, dust, fumes, and other conditions that could be calculated to search out and expose any motor failing. They are tough motors, proving their toughness in hundreds of applications as difficult as that shown above.

HALF CENTURY OF 1901 EC 1951 POWER PROGRESS

MR-10

Company

SPRINGFIELD, O. • NEWARK, N.J.

PRINCIPAL CITIES

CROCKER-WHEELER DIVISION

AMPERE, N. J.

LINDE'S News of Metalworking

Braze-Welded Repair Saves Six Months' Production Time

When the base of a 5-ton alligator shear cracked in service, early return to normal plant operation appeared hopeless. Delivery of a new shear was six months away . . . cost $1,800.

But LINDE service engineers suggested braze-welding. Within a few days the shear was back in service—permanently repaired at a cost of only $355. This single braze-welding job saved the manufacturer $1,445 and six months of valuable production time.

Similar typical savings account for widespread industrial acceptance of braze-welding as a quick, easy way to join steel, cast iron, malleable iron, and many dissimilar metals. And routine repairs by braze-welding are often made without dismantling machines. Shut-down time is always kept to a minimum.

Why not save the cost, delivery, and installation time required for that new part? Put the old one back on the job with braze-welding.

Braze-welding is only one of many time- and moneysaving LINDE methods for making, cutting, joining, treating, and forming metals. For further information, call or write our nearest office today.

Replacement of this $1,400 ring gear would have taken more than six months. Braze-welding at half the cost rebuilt badly worn teeth and restored the gear to service in just a few days.

What's News

► One steel company has found their OXWELD C-60 Cutting Blowpipe so effective in reducing large pieces of scrap that they are now purchasing quantities of large-size scrap to process themselves.

► Saran and polystyrene, previously resistant to speedy pulverization, are now being successfully ground by LINDE'S new liquid nitrogen pulverization method. . . . Efficiency is such that the new process pulverizes some previously difficult-to-grind materials at rates over 700 lb. per hr.— using small mill hammers.

► Magnesium hydraulic systems for landing gears were formerly discarded at an airplane shop when pinhole leaks appeared. Now, thanks to HELIARC welding they're repaired at a saving of $500 each.

"LINDE" SERVICE DOESN'T COST — IT PAYS!

LINDE AIR PRODUCTS COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

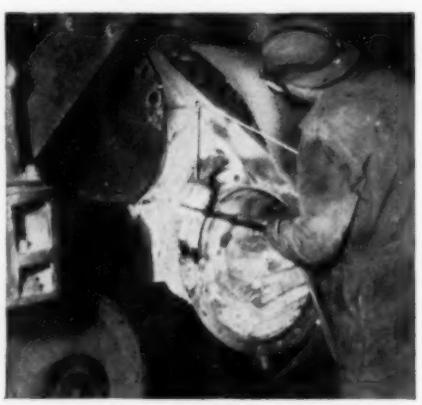
"Irreplaceable" Cylinder Back at Work in 20 Hours

It looked as if "old faithful" was headed for the scrap pile when overworked pistons snapped and cracked the cylinder of a 1904 model railroad locomotive. To replace the cylinder would have been next to impossible. But braze-welding had "old faithful" back at its lumber mill job in only 20 hours.

Repairs were made without dismantling. After the crack was prepared for welding, the cylinder was covered with asbestos paper and preheated. Then the crack was welded, and the cylinder rebored. Total preheating and welding time was 13 hours.

Repairs cost only $138, including materials, labor, and overhead. Even if the cylinder could have been replaced—at a cost over $4,000—the locomotive would have been idle many months instead of the few hours required to make the repair.

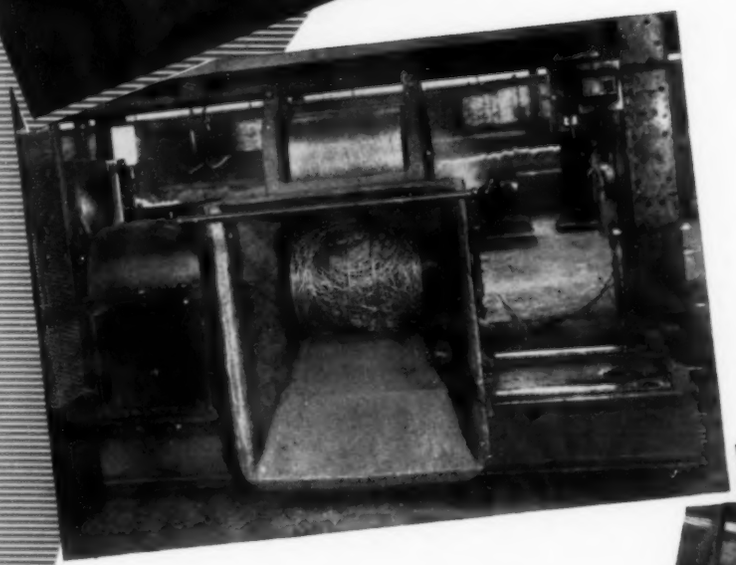
Rapid repair of unavailable or hard-to-get parts is a natural job for braze-welding. Try it yourself, next time you're bothered with a troublesome replacement problem.



Braze-welding this locomotive cylinder without dismantling saved a lumber company more than $4,000. On special jobs like this, LINDE service and supervision assures success.

The terms "Heliarc," "Linde," and "Oxweld" are registered trade-marks of Union Carbide and Carbon Corporation.

CLEARS COBBLES in a HURRY!



When a red hot bar starts whipping around the mill—everybody ducks. Production comes to a standstill until the cobble is cleared away.

Yes, this happens occasionally . . . even in a Morgan mill. But, Morgan has a special treatment for handling the situation . . . speedily and safely.

At the touch of a button the new Morgan Electric Crop and Cobble Shear begins chopping that part of the cobbled bar still coming through the mill. The sheared lengths drop into the charging box below. At the same time the new Morgan Cobble Bundler quickly winds the balance of the cobble into rolls that can be easily handled and placed in open hearth charging boxes.

Other Morgan innovations that contribute to efficient rolling mill operation will be discussed in future advertisements. If you can't wait, let us tell you about them now. Just write:

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

Rolling Mills - Morgoil Bearings - Wire Mills
Regenerative Furnace Control - Gas Producers - Ejectors

English Representative: International Construction Company
56 Kingsway, London, W.C. 2, England

RM-39

TREADWELL

200 NET TON OPEN HEARTH LADLES

Hot Metal, Hot Metal Transfer, Bessemer
Open Hearth and Electric Furnace

LADLES

OF WELDED OR RIVETED CONSTRUCTION

FOR THE STEEL, COPPER, BRASS, ALUMINUM AND ALLIED INDUSTRIES

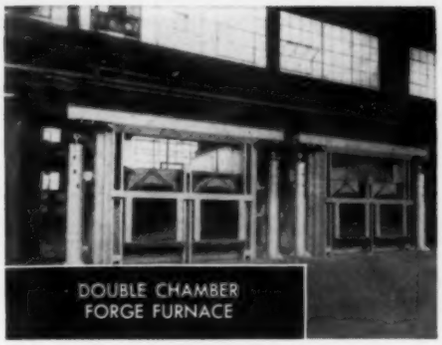
TREADWELL CONSTRUCTION CO.
MIDLAND, PENNSYLVANIA

SALES OFFICES

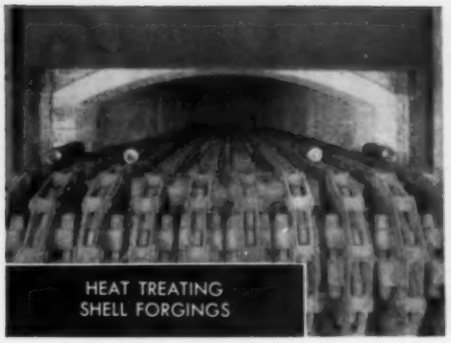
208 So. LaSalle Street
CHICAGO 4, ILL.

140 Cedar Street
NEW YORK 6, N. Y.

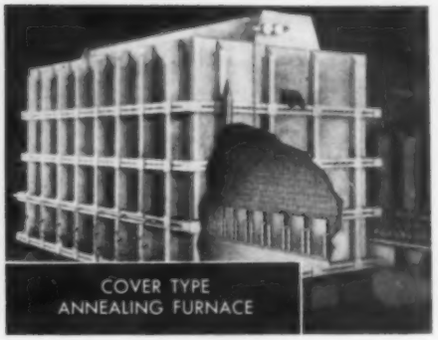
1217 Farmers Bank Building
PITTSBURGH 22, PA.



DOUBLE CHAMBER FORGE FURNACE

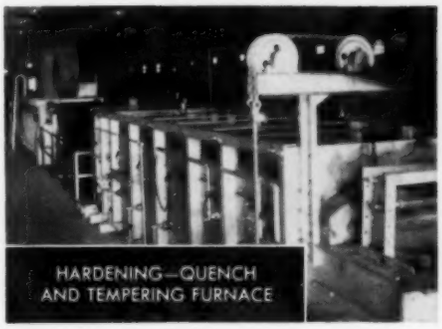


HEAT TREATING SHELL FORGINGS



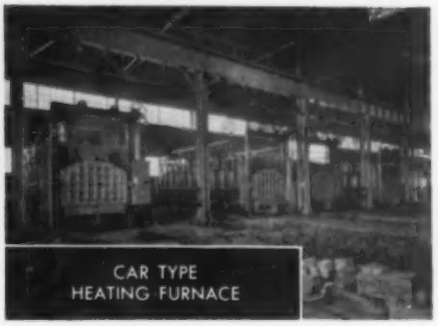
COVER TYPE ANNEALING FURNACE

AMCO Designs, Erects and Operates



HARDENING—QUENCH AND TEMPERING FURNACE

OPEN HEARTH STEEL FURNACES

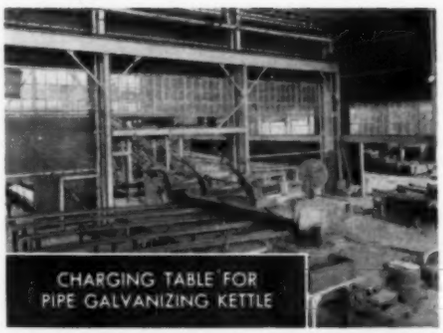


CAR TYPE HEATING FURNACE

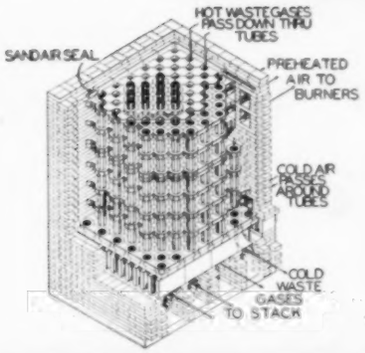
Recognized for 36 years as the world's foremost builder of Industrial Furnaces

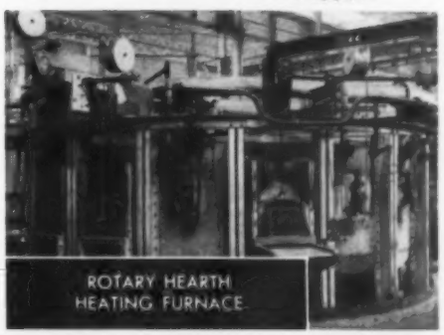
Get our NEW pictorially described literature

BULLETIN 295



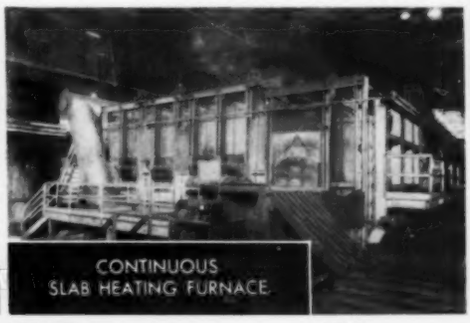
CHARGING TABLE FOR PIPE GALVANIZING KETTLE


HOT WASTE GASES PASS DOWN THRU TUBES
SANDAR SEAL
PREHEATED AIR TO BURNERS
COLD AIR PASSES AROUND TUBES
COLD WASTE GASES TO STACK



ROTARY HEARTH HEATING FURNACE

INGOT HEATING FURNACES



CONTINUOUS SLAB HEATING FURNACE

PULVERIZED COAL FIRED CONTINUOUS BILLET HEATING FURNACE

Amsler Morton Corporation

CHAMBER OF COMMERCE BLDG., PITTSBURGH 19, PA.

STOP RUST

FREE SURVEY: Place your rust problems in the hands of a **RUST-OLEUM** specialist. He will survey your plant for all rust problems, submit detailed recommendations, and make specific tests.

You can stop rust with RUST-OLEUM! An exclusive formula proved in a wide range of industrial and marine applications for more than 25 years. Its tough, pliable film dries to a firm rust-resisting coating that protects against rust—cuts maintenance costs—adds years of use to many metal surfaces, indoors and outdoors.

RUST-OLEUM may be applied over rusted surfaces without removing all the rust, assuring substantial savings in preparation time... It is only necessary to remove all the rust scale and loose rust.

Prompt delivery from Industrial Distributor stocks in principal cities. See *Sweets* for complete catalog and nearest source of supply, or write for complete literature on your company letter head today!

Beautifies AS IT PROTECTS

Available in many **COLORS,** aluminum and white

RUST-OLEUM CORPORATION

2441 Oakton Street, Evanston, Illinois

"Rigid Economy, Mon"

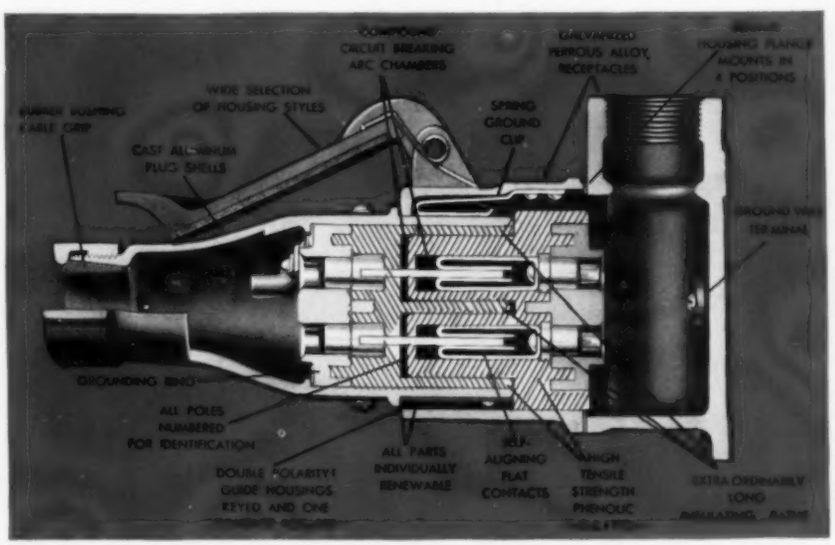
SAFE • DURABLE • DEPENDABLE

PYLE-NATIONAL

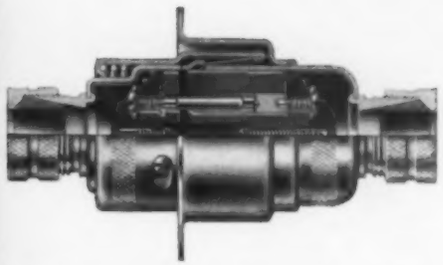
Heavy Duty Plugs and Receptacles

FOR PORTABLE ELECTRICAL EQUIPMENT

Pyle-National plugs and receptacles are built to withstand the most severe operating conditions, as proven by years of remarkably dependable service in a wide variety of industrial applications. The many substantial construction features of this extensive line of plugs and receptacles and the high quality of materials and workmanship insure safe operation, uninterrupted service and long life.


COMPOUND CIRCUIT BREAKING ARC CHAMBERS
GALVANIZED FERROUS ALLOY RECEPTACLES
HOUSING FLANGE MOUNTS IN 4 POSITIONS
WIDE SELECTION OF HOUSING STYLES
SPRING GROUND CLIP
CAST ALUMINUM PLUG SHELLS
GROUNDING RING
ALL POLES NUMBERED FOR IDENTIFICATION
DOUBLE POLARITY GUIDE HOUSINGS KEYED AND ONE
ALL PARTS INDIVIDUALLY RENEWABLE
SELF-ALIGNING FLAT CONTACTS
HIGH TENSILE STRENGTH PHENOLIC
EXTRA ORDINARILY LONG

QuelArc* • *Circuit Breaking Series* **Unique partitioned insulation provides long insulated paths through air and across surfaces for exceptional protection in these current rupturing devices. Cast metal housings, high grade insulation and individually renewable contacts insure long service life. Ratings 20, 30, 60, 100 and 200 amperes, 250 volts DC, 600 volts AC—2, 3, and 4 pole—grounded through shell or extra pole. Threaded cap, plain and hinged spring door housing styles are available.**

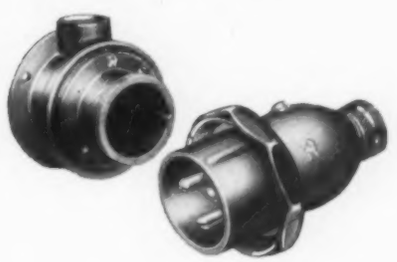


Interchangeable reversible contact units. 1, 2, 3, 4, 6, 8 pole

Triploc* *and Multiple-Circuit Series*

A line of exceptional versatility, unequalled in the heavy duty field, with a virtually unlimited number of assembly combinations for varied applications. Offers a selection of 1, 2, 3, 4, 6 and 8 pole contact units which are interchangeable and reversible in any single set of housings. Many types of housings available of pressed steel with automatic lock and of cast metal threaded for watertight gasket seal. Multi-Circuit housings with 2, 3 and 4 contact units available for combinations up to 32 poles. Ratings 15 and 20 amperes, 250 volts DC, 460 volts AC—circuit breaking. Pressed steel fusible and fuseless plugs measure only 1 13/16" outside diameter.

Midget Triploc* *Series* **Same construction features as Triploc except for much smaller outside diameter of plug shell—only 1¼". Interchangeable and reversible contact units—2, 3 and 4 pole—are of the flat blade type. Rated 10 amperes, 250 volts; 15 amperes, 125 volts.**



General Purpose *Series* **Available with cast metal housings in many types for circuit breaking and disconnect service. 30 amperes, 125 volts DC, 250 volt AC—1, 2, 3, 4, 5 and 6 pole. 60 amperes, 250 and 600 volts—3, 4 and 5 pole. 100 ampere, 250 and 600 volts—2, 3 and 4 pole. Also many special types, fusible and fuseless, for varied applications.**

*TRADEMARK REG. U. S. PAT. OFF.

THE PYLE-NATIONAL COMPANY

1383 NORTH KOSTNER AVENUE, CHICAGO 51, ILLINOIS

BRANCH OFFICES AND AGENTS in principal cities of the United States and Canada. • EXPORT DEPARTMENT: International Rail Supply Co., 30 Church St., New York. • CANADIAN AGENT: The Holden Co., Ltd., Montreal

CONDUIT FITTINGS • FLOODLIGHTS • TURBO-GENERATORS • GYRALITES • MULTI-VENT AIR DISTRIBUTION

Cleveland Cranes
FOR
STEEL MILL SERVICE
CLEVELAND
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

W. G. VOLLMER, president of the Texas and Pacific Railway Company, sums up his "four pillars of freedom" thus:

"Let's work hard and earnestly at the task of strengthening ourselves spiritually, morally and economically.

Let's save our free American way of life, no matter what the sacrifices may be.

Let's vote at every election for people who place the welfare of their country above their personal political welfare.

Let's pray for the wisdom and courage to do our duty as good Americans, faithful to God and to our country."

▲

RECENTLY we received a check in payment for 1951 dues. On the back of the invoice which was returned with the check was a penciled list of spring chores, such as plant seeds, fertilize lawn, work on terrace, plant basil and portulaca, cut grass, etc. We hope that the lawn and garden thrived, and we're happy to know that our invoices are so useful, but we hope we don't find any with Christmas gift lists on them.

▲

WITH summer drawing to a close, we still haven't doped out what keeps the girls' bathing suits in place. There doesn't seem to be any hooks, although we can vouch for innumerable eyes on them.

▲

A LARGE industrial concern discovered that nine out of ten cases of workers' inefficiency were caused by worry. A life insurance company found that four out of five nervous breakdowns began not in actual events but in worry. A medical clinic's analysis of its patients showed that 35 per cent of all illness on its records started with worry.

And now that we've learned how serious the affects of worry can be, we'll worry about the possibility of our starting to worry.

▲

A LOT of men say they want to die with their boots on — but too many die with one boot on the accelerator pedal.

▲

IMPORTS of iron ore from Venezuela, which began in March, are expected to rise to more than 10 million tons annually when mining operations are in full swing two or three years hence.

It is believed there is more iron ore in the area near the junction of the Orinoco and Caroni rivers than has been produced from Lake Superior's Mesabi Range in its 66 year history. Two major Venezuelan deposits are being tapped by steel companies from the United States, while two other American steel firms and an ore company are also exploring the district.

▲

IF a man makes ten consecutive correct guesses, he's on a fair way to establishing a reputation as an expert — which will last until he makes one little mistake. William Feather says: "When I am wrong I get a hundred letters but when I'm right, I'm ignored."

It can be a short trip from hero to zero.

▲

A NEW holiday may be added to the lengthening list if members of Local No. 1, C.I.O. United Packinghouse Workers of America, obtain their demands from John Morrell & Company of Ottumwa, Iowa. The union is requesting a paid eight-hour holiday on each employee's birthday.

This is the same union that asked for a free 15 lb ham for each employee on Christmas and Easter, as well as two hours paid travel time for each employee for each working day, a paid 30 minute lunch period, and free lunches (or $1.00 instead) for all.

What? No paid time for shaves and haircuts.

▲

THERE'S food for thought in the statement of a termite authority to the affect that termites are probably the oldest insect, the remains of some having been found in amber estimated to be 10,000,000 years old. He says the reason the species has lasted so long may be that they never fight with each other.

▲

THE new edition of "Occupational Outlook Handbook," published by the Government Printing Office, reverses its 1949-edition statement that there are too many engineering graduates and too few jobs. The 1951 edition recommends engineering, teaching and medicine, saying that engineering is the most critical manpower shortage. The book now advises steering clear of law, newspapering, radio announcing, photography, stonemasonry, plastering, painting and paperhanging.

▲

IT may be something of a jolt, but a recent survey made by Northwestern National Life Insurance Company, shows that only one American breadwinner out of four likes the idea of retiring to a life of complete leisure when he grows old. The results also show that a life of Riley appeals more strongly to younger men.

▲

ONE of our correspondents observes that peroxide makes blondes, henna makes redheads and gin makes both.

6 point Temperature Recorder

with single-point vigilance

THE MULTI-RECORD DYNALOG*

By recording up-to-6 points in rapid succession, the Foxboro Multi-Record Dynalog gives the immediate warning of temperature drifts that you'd expect only from single-point recorders . . . all 6 records appear like unbroken lines! Check these outstanding features:

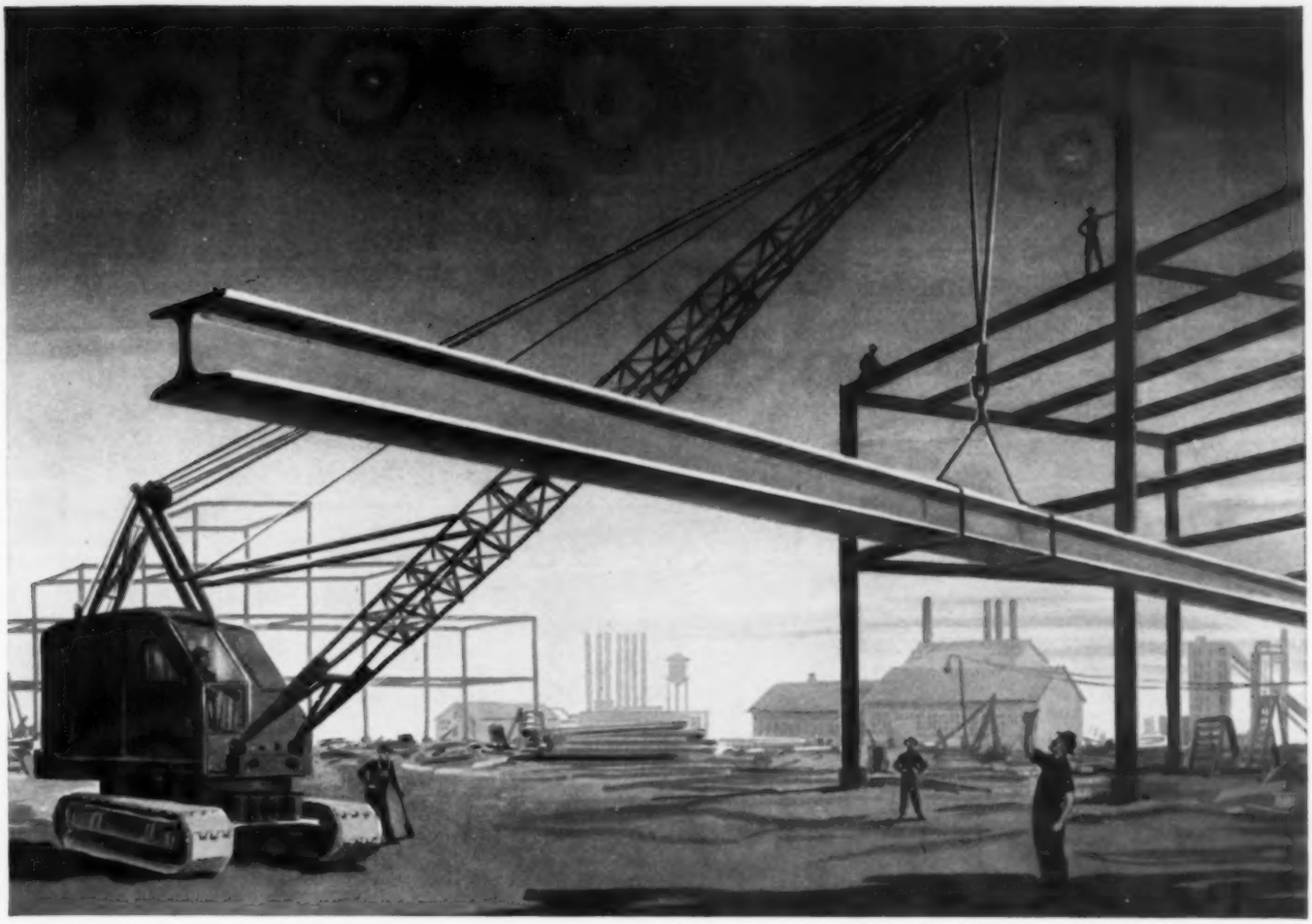
- **High speed recording—6 seconds between prints for maximum continuity of records**
- **Each record in a distinctive, non-smudging color**
- **Unique electronic circuit requires no standardizing, battery, galvanometer, or slide wire . . . gives STEPLESS continuous balancing**
- **Unmatched accuracy, lowest maintenance, greatest convenience**
- **Thermocouple and resistance-bulb types**
- **Uses convenient, low cost circular charts**

Get the *full* story. Write for Bulletin 427-1. **The Foxboro Company, 589 Neponset Avenue, Foxboro, Mass., U.S.A.**

*Reg. U. S. Pat. Off.

Another **FOXBORO** *FIRST*

Reg. U. S. Pat. Off.



KULJIAN ENGINEERING gives a lift to STEEL

"Giving a lift" to a neighbor is an old term for helping when an emergency arises. The demands being made on the Steel Industry today amount to an emergency of a kind in which the Kuljian organization is best fitted to "give a lift."

Increased production calls for plant extensions and modifications, all requiring engineering services of an experienced and specialized type. Kuljian offers its services to relieve the extra load on your regular engineering staff. Not only additional engineering manpower but seasoned competence and ability to assume complete responsibility for design and supervision of large projects, are made available at a time when they are most needed and hardest to find. Your phone or a letter will bring a Kuljian engineer to your desk promptly for consultation without obligation.

KULJIAN

WASHINGTON, D.C.
CALCUTTA, INDIA
ROME, ITALY
CARACAS, VENEZUELA
MEXICO CITY, MEXICO

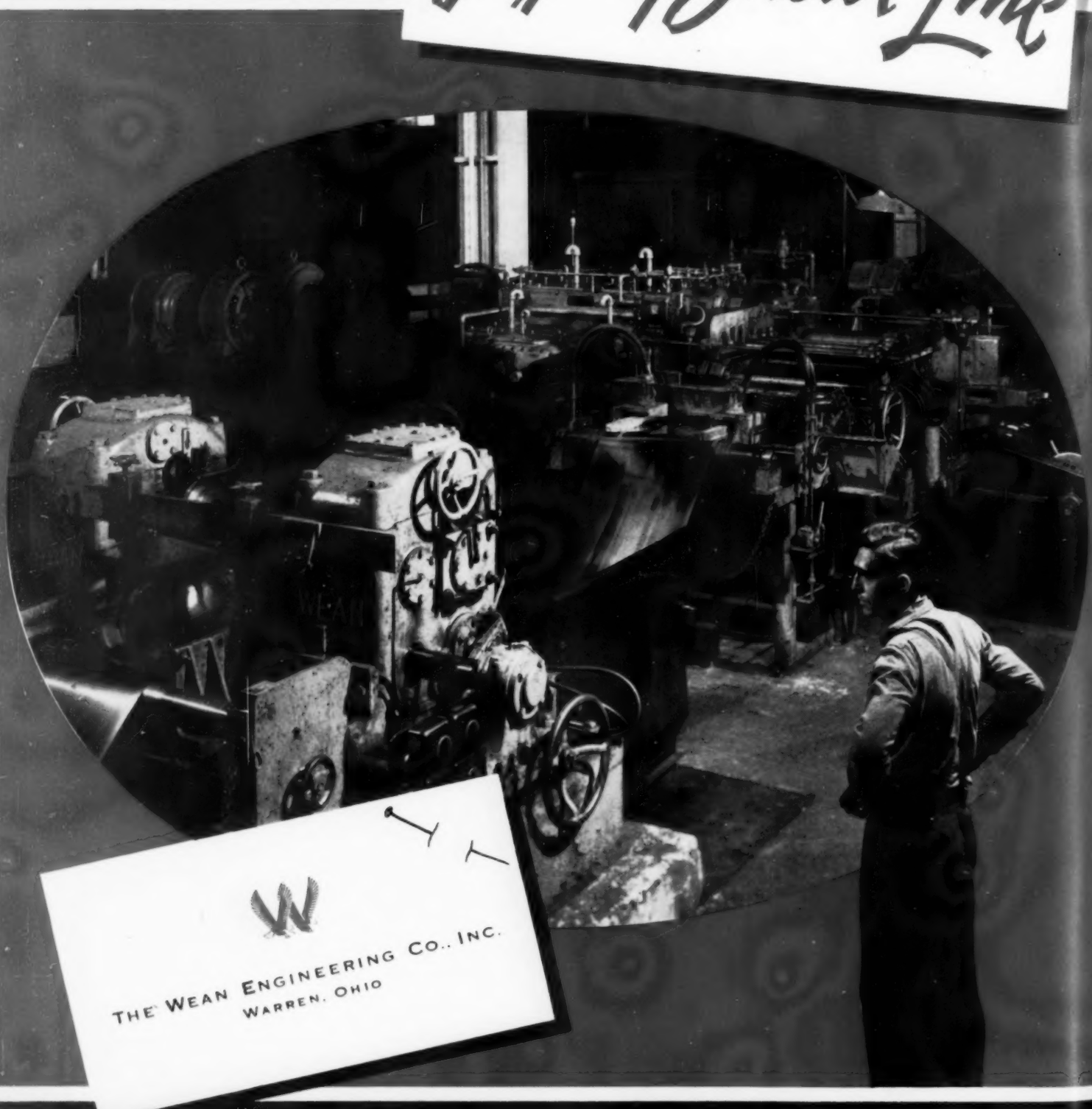
The **Kuljian** *Corporation*

ENGINEERS

1200 NORTH BROAD STREET, PHILADELPHIA 21, PA.

WEAN-HALLDEN TIN PLATE

Flying Shear Line



SPECIALISTS IN SHEET, TIN and STRIP MILL EQUIPMENT

T. J. ESS, *Editor*
I. E. MADSEN, *Associate Editor*
ALBERT W. ERICKSON, JR., *Production Manager*

Board of Directors

FIRST VICE PRESIDENT, I. N. TULL, *Electrical Superintendent,* Republic Steel Corp., Cleveland, Ohio.

SECOND VICE PRESIDENT, JOHN L. YOUNG, *Vice President — Chief Engineer,* United States Steel Co., Pittsburgh, Pa.

TREASURER, E. L. ANDERSON, *Electrical Superintendent,* Bethlehem Steel Co., Johnstown, Pa.

SECRETARY, JOHN H. VOHR, *General Superintendent,* United States Steel Co., Gary Works, Gary, Ind.

PAST PRESIDENTS: C. H. WILLIAMS, *Chief Engineer, Manufacturing Division,* United States Steel Co., Pittsburgh, Pa.

A. S. GLOSSBRENNER, *Vice President Operations,* Youngstown Sheet and Tube Co., Youngstown, Ohio.

HONORARY DIRECTORS: JAMES FARRINGTON, *Electrical Superintendent,* Wheeling Steel Corp., Steubenville, Ohio.

CHARLES L. McGRANAHAN, *Technical Assistant to Works Manager,* Societe Lorraine de Laminage Continu, Thionville (Moselle), France.

L. P. COFFIN, *Superintendent Mechanical Department,* Bethlehem Steel Co., Sparrows Point, Baltimore, Md.

DIRECTOR-AT-LARGE: W. H. COLLISON, *Superintendent of Coke Plant,* Great Lakes Steel Corp., Ecorse, Detroit, Mich.

DIRECTORS: J. W. JOHNSON, *Assistant Superintendent,* Tennessee Coal, Iron and Railroad Co., Bessemer, Ala.

H. H. NORTHRUP, *Superintendent Open Hearth Department,* Republic Steel Corp., Buffalo, N. Y.

C. W. BRUCE, *Assistant Chief Engineer,* Republic Steel Corp., South Chicago, Ill.

J. H. FRANZ, *Superintendent Fabricating Shops* United States Steel Co., McDonald Works, Youngstown, Ohio.

W. E. HART, *Superintendent Electric Furnace Building,* Ford Motor Co., Dearborn, Mich.

W. E. ZELLEY, *Superintendent Maintenance, Utilities and Construction,* John A. Roebling's Sons Co., Roebling, N. J.

S. C. READ, *Manager, Construction and Maintenance,* Jones and Laughlin Steel Corp., Pittsburgh, Pa.

D. E. WHITEHEAD, *General Lubrication Engineer,* Crucible Steel Co. of America, Pittsburgh, Pa.

C. E. DUFFY, *Fuel Engineer,* Bethlehem Steel Co., Sparrows Point, Md.

V. E. SCHLOSSBERG, *Assistant Chief Engineer,* Inland Steel Co., East Chicago, Ind.

F. E. ROBINSON, *Assistant Division Engineer,* American Steel and Wire Co., Cleveland, Ohio.

WADE F. HOFFMAN, *Superintendent Roll Department,* Jones and Laughlin Steel Corp., Aliquippa, Pa.

R. R. THOMAS, *Assistant Chief Engineer, Manufacturing Division,* Tennessee Coal, Iron and Railroad Co., Ensley, Ala.

Managing Director
T. J. ESS
Empire Building
Pittsburgh, Pa.

Iron and Steel ENGINEER

SEPTEMBER, 1951 VOLUME XXVIII NUMBER IX

In This Issue

Blast Furnace Inwall Rebuild at Algoma — by D. Joyce, Assistant Superintendent of Blast Furnaces, and, J. Laidlow, Staff Assistant, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada 75
Hard Facing Alloys for Steel Mill Use — by Howard S. Avery, Research Metallurgist, American Brake Shoe Co., Mahwah, N. J. 81
Laboratory Screening of Multi-purpose Greases — by E. M. Kipp and C. A. Zeiler, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa. 107
Extreme Pressure Lubricants — by James H. Lewis, General Foreman, Maintenance Mechanical, United States Steel Co., Clairton, Pa. 114
What to Look for in Hydraulic Fluids — by Anthony J. Zino, Jr., Swan-Finch Oil Corp., New York, N. Y. 119
Dry Cleaning with Corn Cob Grits — by Edgar W. Shoff, General Foreman, Electric Shop, Gary Sheet and Tin Mills, United States Steel Co., Gary, Ind. 126
Lubrication of Wire Rope — by Joseph A. Rigby, Vice President, The Brooks Oil Co., Pittsburgh, Pa. 131
Lighting of Steel Mill Buildings — by Davis H. Tuck, Chief Electrical Engineer, Holophane Co., New York, N. Y. 133
Heating of Steel Mill Buildings — by George J. Campbell, Assistant Fuel Engineer, Bethlehem Steel Co., Sparrows Point, Md. 139
Ventilation of Steel Mill Buildings — by William S. Johnson, Industrial Hygienist, Bethlehem Plant, Bethlehem Steel Co., Bethlehem, Pa. 145
Program — 1951 AISE Convention 150
Abstracts of Papers to be presented at AISE Annual Convention 158
Lubrication and Maintenance of Bearings — by L. E. Lovitt, Socony-Vacuum Oil Co., Inc., Pittsburgh, Pa. 169
Maintenance of Roller Bearings in Steel Plants — by Paul L. Haager, Assistant Chief Engineer, Timken Roller Bearing Co., Canton, Ohio 172
Portable Breathing Unit Aids Furnace Repairs 198
Date-Line Diary 203
Industry News 207
Personnel News 231
Equipment News 269
AISE New Members 276
Index to Advertisers 281

Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expressions of contributors for which the Association of Iron and Steel Engineers assumes no responsibility.

Copyright, 1951 The Association of Iron and Steel Engineers.

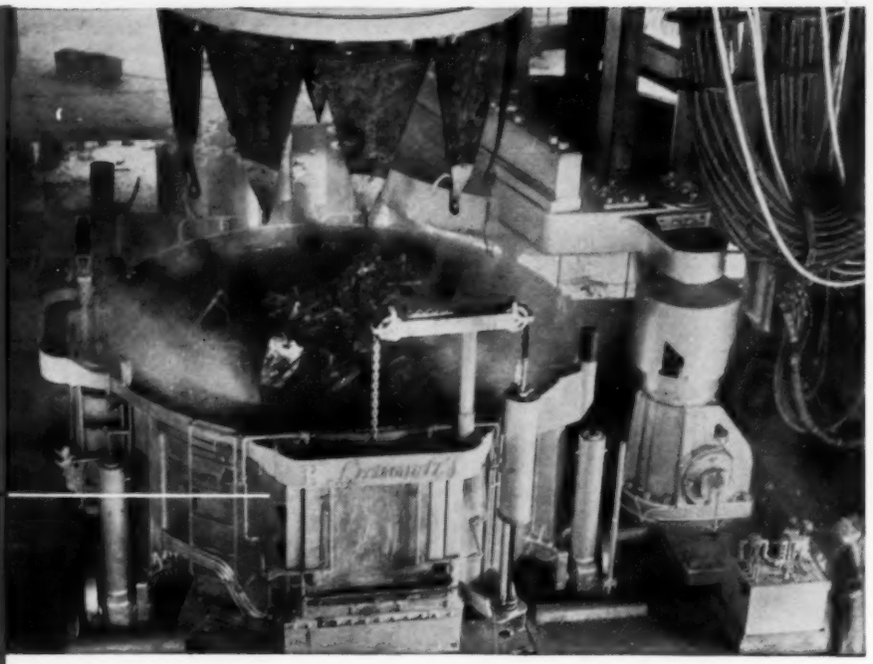
Indexed by Engineering Index and by Industrial Arts Index.

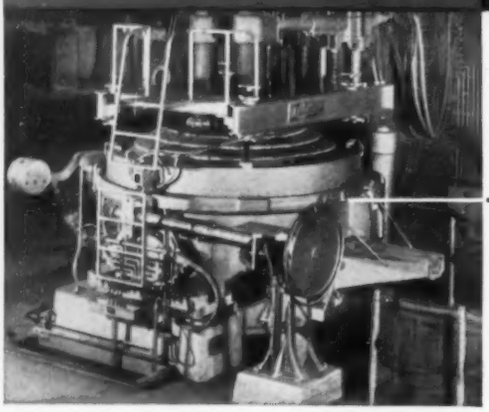
Single Copy Foreign Prepaid $2.00 Single Copy $1.50
Subscription price in U. S. and Canada (U. S. Funds) ..... $ 7.50 per year
Subscription price in foreign countries ..... $10.00 per year

PLASTIC BINDING U. S. PATENT NO. 1970285 LICENSE NO. 120.

if you need 'em

BIG





...if you need 'em little

LECTROMELT Builds Furnaces up to 150-ton Capacity

ALL WITH LABOR-SAVING, TOP-CHARGING DESIGN . . .

No matter what the size of your heats, Lectromelt builds a furnace to handle it—up to 150-ton heat capacity.

Lectromelt* furnaces are top-charging design, giving you tremendous man power savings. Says one foundry superintendent, "I'd need labor at 40c an hour if we didn't have top charging on our furnace."

Lectromelt furnaces offer you all these additional moneysaving advantages; engineered and correlated electric power system; counterbalanced electrode arms; oil-bearing-mounted top structure; side-mounted tilting mechanism.

We'd be glad to talk over your melting, refining, smelting and reduction problems. Just write Pittsburgh Lectromelt Furnace Corporation, 310 32nd Street, Pittsburgh 30, Pennsylvania.

Manufactured in . . . CANADA: Lectromelt Furnaces of Canada, Ltd., Toronto 2 . . . ENGLAND: Birlec, Ltd., Birmingham . . . SWEDEN: Birlec, Elektkougnar A/B, Stockholm . . . AUSTRALIA: Birlec, Ltd., Sydney . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Belge Stein et Roubaix, Bressoux-Liege . . . SPAIN: General Electrica Espanola, Bilbao . . . ITALY: Forni Stein, Genoa.

*REG. T. M. U. S. PAT. OFF.

MOORE RAPID

WHEN YOU MELT... *Lectromelt*

BLAST FURNACE INWALL REBUILD AT ALGOMA

. . . . the inwall of No. 5 furnace was replaced without removing the stock line section . . . .

By D. JOYCE
Assistant Superintendent of Blast Furnaces

and

J. LAIDLOW
Staff Assistant
Algoma Steel Corp., Ltd.
Sault Ste. Marie
Ontario, Canada

▲ NO. 5 Blast furnace inwall was rebuilt in August 1949. This furnace, the lines of which are shown on Figure 1, has a 25-ft diam hearth and is of the following dimensions:

Diameter of hearth	25 ft 0 in.
Diameter of bosh	28 ft 0 in.
Height of bosh	10 ft 0 in.
Height of barrel above bosh	8 ft 0 in.
Diameter of throat	19 ft 8 in.
Diameter of large bell	14 ft 6 in.
Angle of bosh	81 degrees 28 ft 9 in.
No. of tuyeres	16
Working volume	35,473 cu ft

During the early months of 1949 it became increasingly evident from furnace operations that the furnace had become scaffolded. Operation was such that it was impossible to blow the furnace for any extended period above 64,000 cfm. Between 61,000 and 64,000 cfm, it was possible to maintain conditions somewhat approaching satisfactory and economic work, and to produce consistent tonnage of fair quality iron with sulphur below 0.050 max specification for extended periods. Even on this lower wind range, however, the furnace required constant attention to check at once any tendency to channel or side drive. On higher wind ranges of 68,000 to 70,000 cfm channeling and side driving soon developed, with consequent high flue dust losses and off grade iron.

LOCATING SCAFFOLD UNDER OPERATING CONDITIONS

Proof of suspected scaffold and its location was accomplished in March 1949, when, on examining the stockline wearing plates and top inwall lining, a shelf of scaffold could be seen 22 feet below the bottom of the large hopper. This shelf was approximately 24 in. thick and extended from above No. 1 tuyere near the tapping hole to No. 7, being heaviest directly above No. 4, 5 and 6 located under the skip bridge on the west side of the furnace. On June 1st, 1949, further proof of scaffolding was available when, with the furnace down for mechanical repairs, a stack cooling plate in the seventh row at 21 ft 9 in. above the mantle and above No. 5 tuyere was pulled for examination of lining conditions.

Here, on burning with an oxygen lance, scaffolding was apparent, the scaffold being of laminated formation, affording some times fairly easy penetration with the lance, while on other occasions, lancing was accomplished with great difficulty.

Throughout the lancing operation, cyanide fumes were most noticeable, as is the case in many scaffold formations.

Inwall lining at this point was originally 4 ft 1½ in. thick, with the nose of the cooling plate 36 in. from the shell. The original brick covering the nose of the plate had disappeared; lancing thus commenced 36 in. from the shell, and a distance of 32 in. was penetrated without piercing through the scaffold. This lancing operation took three hours and some 180 ft of pipe were consumed to burn this comparatively short distance. No doubt had we used a lance packed with sufficient aluminum, burning and full penetration of the scaffold would have been effected much more rapidly since trials of this nature had given us a penetration of 23 in. through solid concrete, lightly reinforced, in 3½ minutes operating at normal works oxygen pressure of 100 psi, and using a 20-ft long lance.

OPERATION OF THE FURNACE

During the months prior to the furnace coming off for inwall repairs, repeated attempts were made to clean off the walls under working conditions. Various cleaning slugs of scrap, coke and converter slag were used, along with spells of reverse charging and coke on the bell first. These were no doubt effective in cleaning off part of the scaffold formation and in cleaning off the bosh walls. This was apparent by the dirty flushes and tuyere conditions at times when working through the various cleaning slugs, and also by some improvement in furnace operating condition. The major scaffold was, however, too high in the stack to be removed by such means alone. Efforts were made, due to this high location of the scaffold, to direct gas flow predominantly on the scaffolded side by alterations in blast distribution at the tuyeres; in this respect best results were attained by restriction of No. 11, 12 and 13 tuyeres to 5½ in. diameter, these tuyeres being located directly opposite to the scaffolded area, and by the use of 6½ × 12 in.

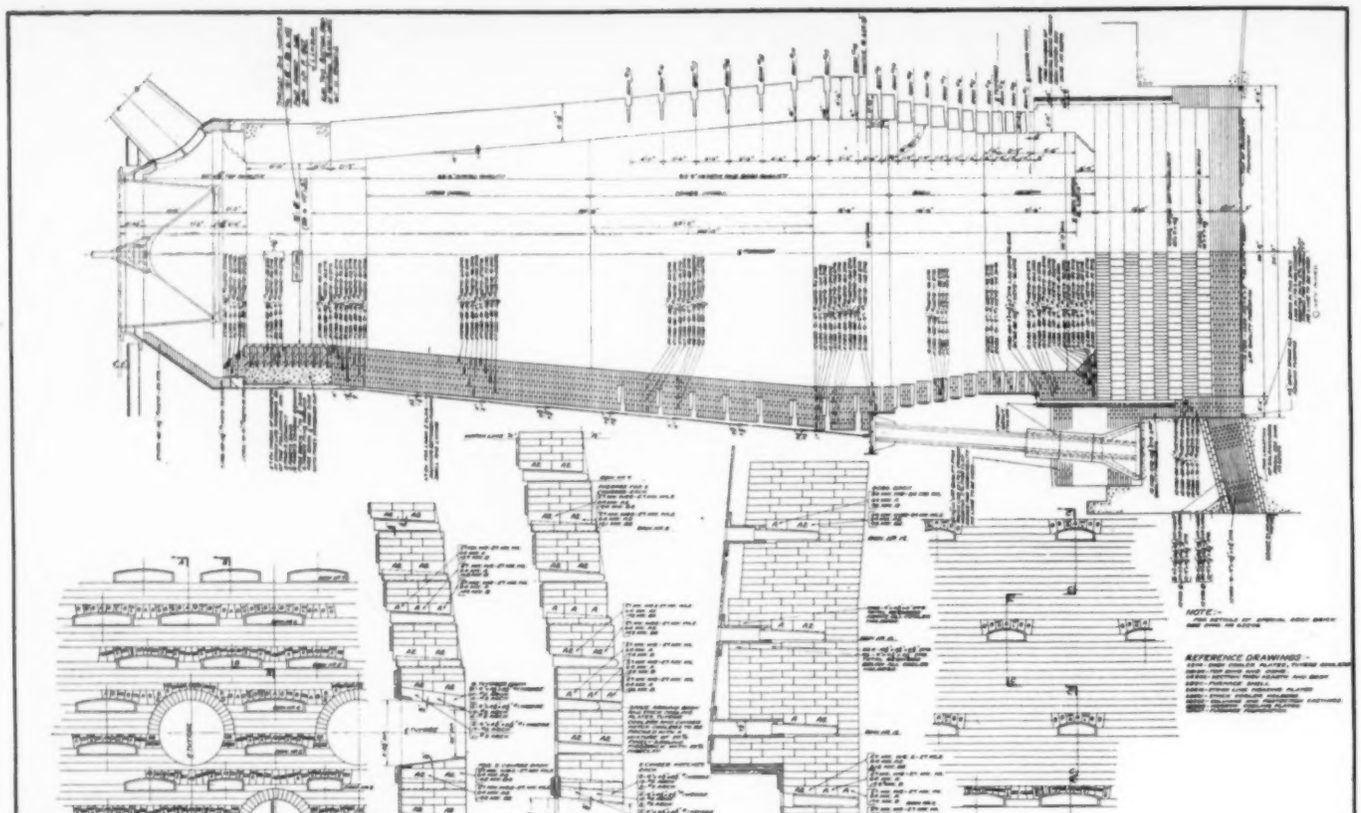
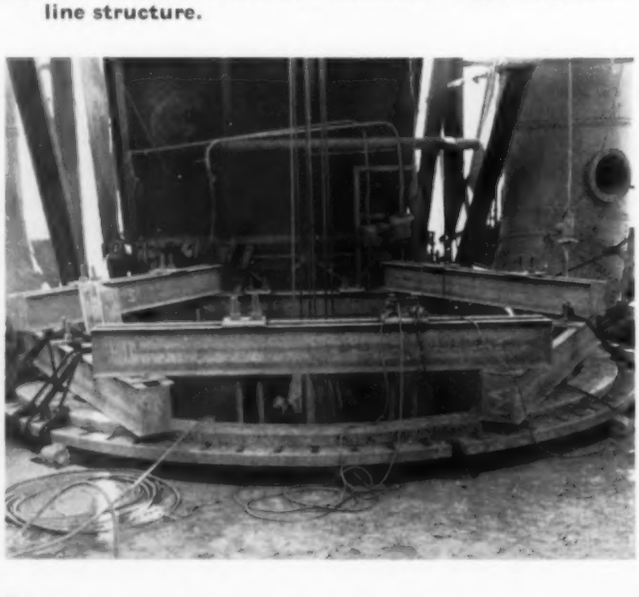


Figure 1 — No. 5 blast furnace has a 25-ft hearth.

tuyeres in No. 3, 4, 5, 6 and 7, directly under the heaviest portion of the scaffold. Apart from these latter tuyeres, all others were 15 in. long. Tuyere velocities of around 135 to 140 cu ft per sq in. tuyere area were most beneficial; with this setup there was a distinct tendency to promote smoother operation and to reduce channeling, thus allowing some increase in blowing rate, increased production and reduced flue dust losses. But even so, control of operation was at times difficult, primarily due to slag conditions. The furnace has two slag notches, one below No. 4 and 5 tuyeres on the west side and directly under the scaffolded area, the other below No. 13 and 14 tuyeres on the east side — both notches being at the same elevation. Practice was to make a flush from each notch prior to cast, but due to furnace condition at times, difficulty was encountered in opening the west notch and in obtaining a normal flush from this side, where slag was generally hotter and more limey than from the east notch where no trouble in flushing was present.

Figure 2 — Photograph shows method of supporting stock-line structure.



The furnace was, in fact, giving two different slags of different formation temperature, a factor which must have been of significance in the formation of the primary bosh slags. The following table gives typical chemical variations in the flush slags produced:

	East	West
Silica	37.34	30.26
Alumina	13.48	14.31
Iron	0.60	0.30
Manganese	0.44	0.17
Sulphur	1.42	1.79

Although some variation in slag quality can be expected at times from different notches on the same furnace, control in this case with operating conditions requiring constant attention was particularly difficult, slags from the east notch perhaps requiring the application of increased blast temperature, whilst the west side called for reduced heat. It was therefore necessary to

strike a medium to produce slags from the east notch good enough to produce grade iron without running into trouble with too hot and limey slags on the west side.

It was somewhat surprising that, under such operating conditions, more trouble was not encountered with cut or sloppy tuyeres, or with slag flooding back in the blow pipes. This demonstrated that, with the tuyere set up previously mentioned, it was possible to maintain a fairly clean hearth with the obvious accompanying advantages to furnace operation. The furnace, moreover, was not prone to tight hanging spells, the tendency being to slipping, rolling and channeling with the occasional blowing through, all undoubtedly caused by the presence of scaffold and the consequent preferential gas flow up the unrestricted side of the furnace. To settle the furnace down from periods of irregular movement, pulling of wind was quickest and most effective. This still holds good on the smooth operation now attained on this furnace.

Throughout the whole of this period, a comparatively heavy charge was employed with a coke unit of 20,000 lb; the sequences primarily employed being:

either 1. OOCCOSCC/Dump
or 2. OOCCOCC/Dump

with stone split on the 3 ore skips. With distributor settings of 8 for sequence 1, and 7 for sequence 2, the furnace seemed to prefer this heavier charge; there was, however, one disadvantage. This four coke charge has a volume of some 1176 cu ft, and gives a theoretical and practical depth of charge over the stockline in the furnace of 3 ft 10 in. Generally, dumping was at 10 ft to 6 ft on each dump. Due to the scaffold formation, however, we did at times run into trouble with charging, when, with the north, south and east rods showing 10 ft, difficulty was encountered in closing the big bell after dumping, due to the charge not clearing the bell on the west side. Evidence of this stockline condition was seen on various occasions when we were inspecting stockline distribution through open bells, but it must be mentioned that on some occasions, no such maldistribution was present, the stockline showing a balanced V contour.

Throughout the whole period of these furnace operations, the stack inwall thermocouples had shown the presence of scaffold. The couples over the scaffolded area recorded some 400 F lower than on the other sections of the furnace. These thermocouples are 6 ft below normal stockline and fitted flush to the working face. Early in the process of endeavoring to overcome this furnace condition, one inwall thermocouple directly above the heaviest scaffold recording only 400 F was inactive for an extended period. Prior to coming off for repairs, however, all inwall couples were active and for periods of short duration, it was possible to obtain a fairly balanced gas flow pattern within the furnace with all four inwall temperatures grouped within 150 F at around 1200 F. Unfortunately, such results could not be maintained long enough to effect any real major change in furnace conditions.

OBSERVATIONS

A new replacement stockline had been built in this furnace in the fall of 1947, when at the same time, the

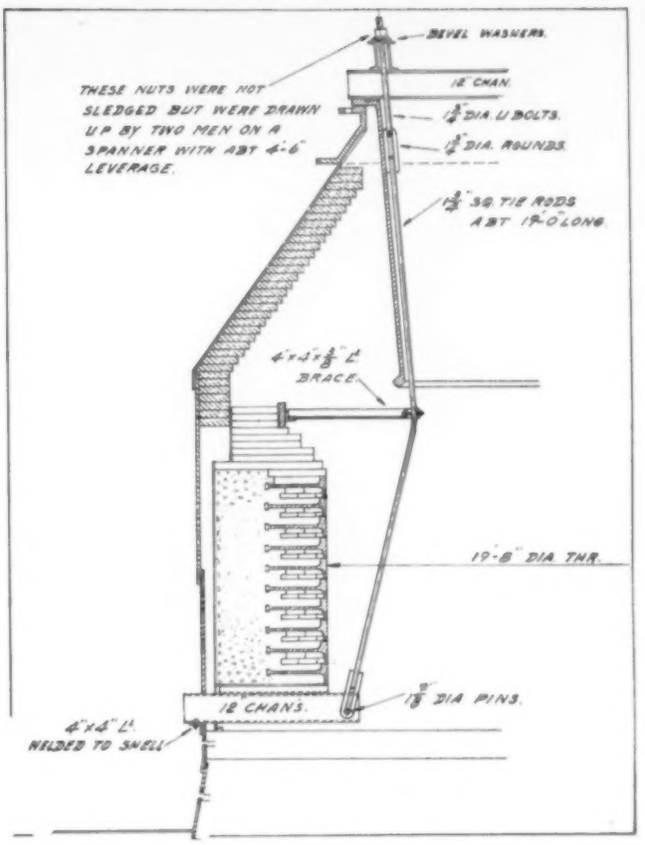
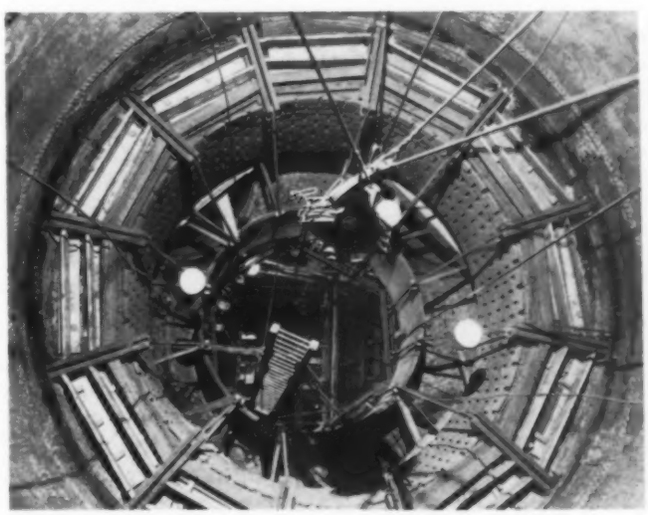

BEVEL WASHERS
THESE NUTS WERE NOT SLEDGED BUT WERE DRAWN UP BY TWO MEN ON A SPANNER WITH ABT 4'-6" LEVERAGE.
12" CHAN.
1 1/4" DIA. U BOLTS.
1 1/2" DIA. ROUNDS
1 1/2" SQ. TIE RODS ABT 19'-0" LONG
4"x4"x 5/8" L BRACE
19'-8" DIA THR.
12 CHANS.
1 7/8" DIA PINS.
4"x4" L. WELDED TO SHELL

Figure 3 — Sketch shows details of stockline supporting structure.

opportunity was taken to increase the stockline diameter from 19 to 19 ft 8 in.; to accomplish this, the furnace was out from October 12 to November 4, 1947. When, therefore, it had been established in June, 1949, that the scaffold condition and inwall lining were such that the furnace had to come off for renewal of the inwall brickwork, the question of suspending the stockline was raised. Examination proved the stockline to be in perfect condition, and hence it was desirable to leave it undisturbed and to renew the lining from the mantle to the underside of the throat wearing plates. In addi-

Figure 4 — Photograph is taken from 30 ft below the stockline and shows how it is supported. View is taken looking upwards.



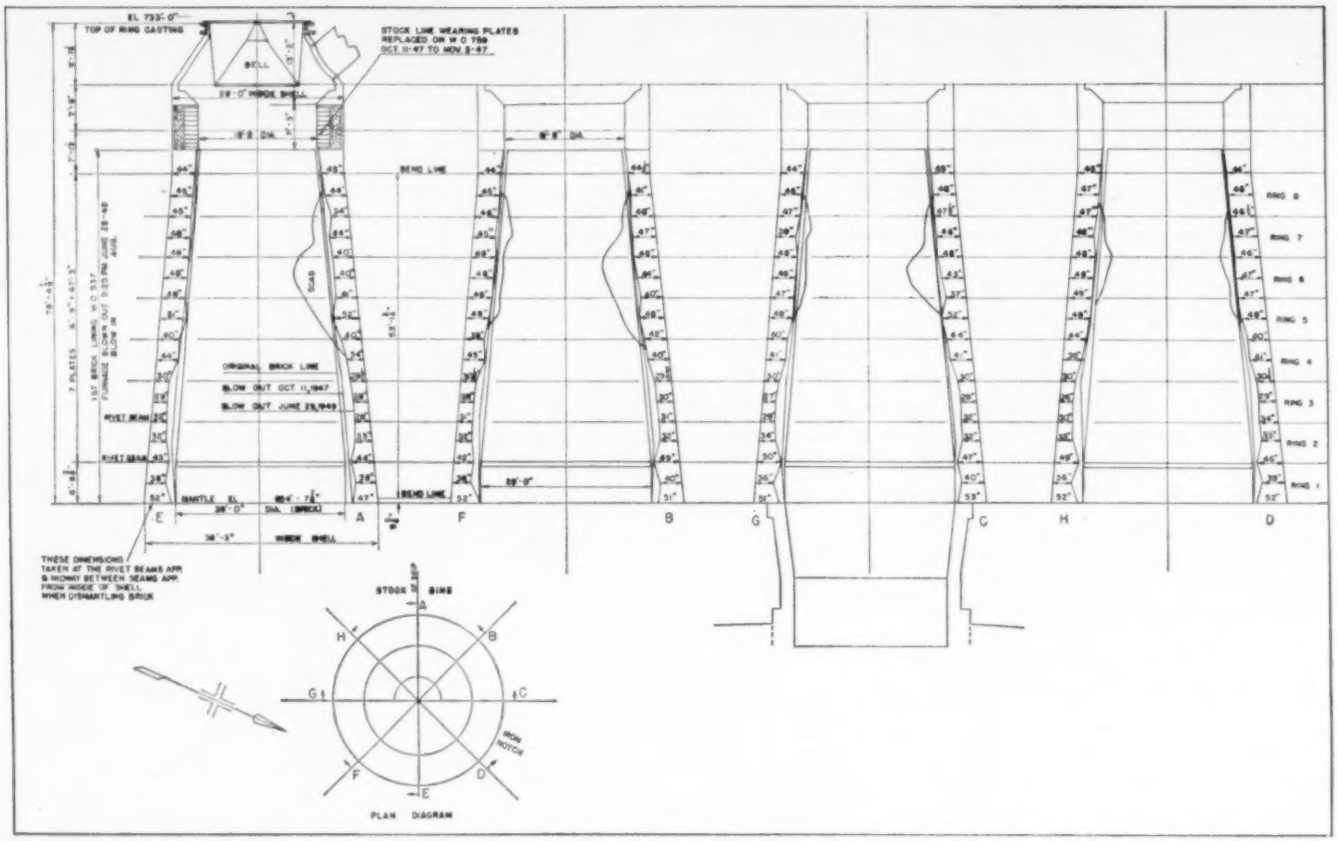


Figure 5 — Sketch shows furnace blowout lines.

tion, it was not desirable to disturb the large bell hopper, which is in four pieces, and which, had it warped on dismantling, would have given us serious trouble in machining, since we did not possess a mill that could swing anything of this diameter and would have necessitated makeshift equipment for refacing.

It was decided, therefore, to suspend the stockline and leave the large bell hopper in position; this of course necessitated the lowering of the large bell to the furnace hearth. This raised an objection from the blast furnace superintendent, since he wished to proceed with the cleaning out of the hearth and any necessary brick patching at the tuyere breast while the new inwall lining was being installed. It was felt that with the big bell lying in the furnace hearth, cleaning of the bottom, etc. would be seriously hampered. However, by supporting the bell on a steel scaffold at tuyere level, this difficulty was overcome. The job was planned accordingly and materials put in hand; repairs were scheduled for 44 days using our own forces throughout. In scheduling the repairs, we would have preferred to arrange for continuous working, three turns per day, but since the required manpower was not available, the schedule called for two eight hour shifts daily, and even at this, riggers and ironworkers were, at times, spread pretty thin. It was also necessary to consider in scheduling that available forces might, at times, be depleted by breakdowns in other sections of the plant; fortunately, this occurred only twice, when bricklayers were called to the open hearths. Everything being ready, the furnace was blown out on June 29, using the nut coke method; flushing out of the nut coke commenced at 9:30 a.m. June 30th, and was completed by 8:30 p.m on that day.

STOCKLINE SUPPORTING STRUCTURE

The stockline was estimated to weigh around 300 tons and the supporting structure was designed accordingly. It consisted of a channel grill carried on the large bell hopper flange and layed out in the form of a hexagon, each leg of which consisted of two 12 in. channels back to back compounded with $\frac{3}{8}$-in. gusset plates. Under the stockline were pitched twelve stringers, again 12 in. channels back to back, the outside ends being carried on the furnace shell and the inside ends by tie rods suspended from the channel grill on top. Grouting troughs were welded on top of each stringer in the form of an inverted channel. The supporting tie rods were $1\frac{3}{4}$ in. square bars, 12 in all, and two carried on each leg of the channel grill. The top of each rod was secured by a long U-bolt, whilst the bottom of each tie rod formed an eye which was located between the channels of the supporting stringer and connected to the same by means of a suitably sized pin. An intermediate brace was fitted to each tie rod back on to the top brickwork just above the top row of throat wearing plates and immediately below the hopper face. Figures 2 and 3 clearly indicate this arrangement.

First, the 12 holes were cut in the furnace shell at the required level, and a hole drilled through the brickwork from the outside to locate the position of each supporting stringer; these initial locating holes were then cut out to desired size to allow positioning of the stringer

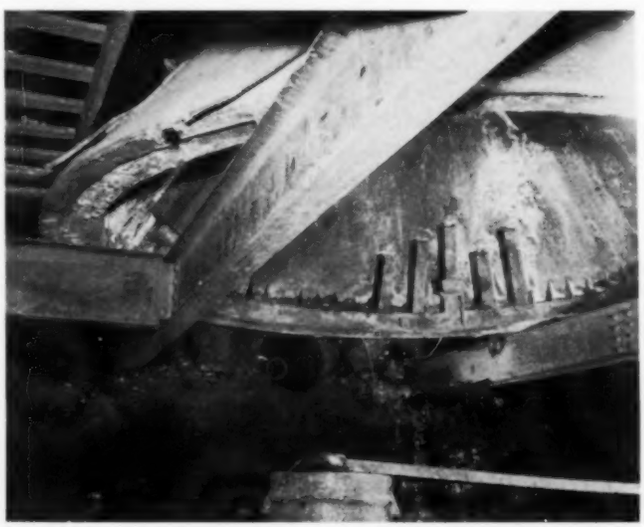
supports, this cutting being done inside the furnace off a hanging scaffold. When the structure was all in place, the U-bolts on the top supporting grill were screwed up, using two men on a wrench with a leverage of 4 ft 6 in. — no sledging was done on these bolts. The grout trough on each stringer was then filled and solidly tamped with a quick setting cement mix.

The intermediate brickwork between each set of stringers was then cut out and H-beams spread between the stringers and welded in, these also having grouting troughs. Immediately behind these intermediate H-beams were also located timber struts so that the whole exposed bottom of the stockline section was secure and made safe, thus ensuring that no pieces of brick or concrete, which might spall off, could fall into the furnace. Figure 4 is a view taken from a scaffold 30 feet below the supported stockline section. The stockline was thus supported on the 9th day after blowing out, meanwhile, the big bell had been lowered in to the furnace hearth on the 6th day, and the major part of the inwall scaffold had been removed from the brickwork face.

CLEARING AND REBUILDING

With the stockline supported, work at once commenced on ripping out the inwall lining, this being done from a hanging scaffold. A close check was maintained on the stockline throughout the repair, but no movement of any kind was apparent. Small pieces of coke and stone, which were lodged between the flanges of the throat wearing plates, when the furnace came off, were marked and remained lodged throughout, thus indicating that little, if any, movement took place. During the period of brickwork and scab removal, constant check was made on furnace blow out lines. Examination of scaffold conditions showed that the scab commenced on the west side at a point 28 ft below the top flange of the main hopper; this, however, was primarily loose material until the 34-ft level, where the real shelf of scab was apparent — this scab extending down the furnace to the 59 ft level with varying thickness especially on the west side of the furnace directly

Figure 6 — The big bell was lowered to the furnace hearth and supported on beams.



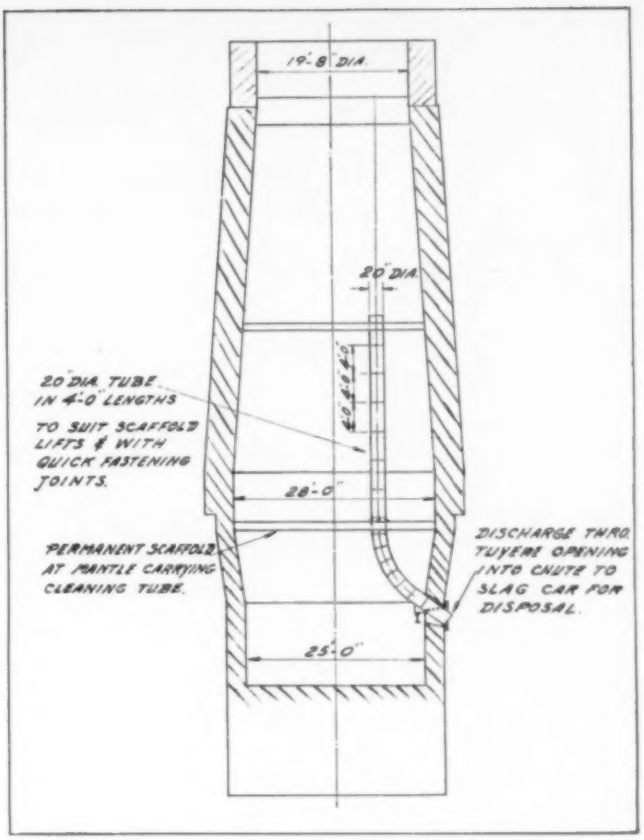

19'-8" DIA.
20" DIA
20" DIA. TUBE IN 4'-0" LENGTHS TO SUIT SCAFFOLD LIFTS & WITH QUICK FASTENING JOINTS.
28'-0"
PERMANENT SCAFFOLD AT MANTLE CARRYING CLEANING TUBE.
DISCHARGE THRO TUYERE OPENING INTO CHUTE TO SLAG CAR FOR DISPOSAL.
25'-0"

Figure 7 — Sketch shows setup for tube chute.

under the skip bridge, and tapering off a thickness to the north and south. Scab was heaviest at the 39 ft 10 in. level, where directly under No. 4 thermocouple on the west side, thickness of the scaffold was 6 ft 3 in. Accompanying this scaffold formation on the west side was a fairly serious erosion of the inwall lining on the east side, particularly on the 57-ft plane. At this point, up to 30 in. of brickwork was missing, this being, no doubt, the outcome of high preferential gas flow. Figure 5 indicates the furnace blowout lines. Examination of the scaffold structure showed a hard skin some 6 to 15 in. thick, often with some loose burden material packed behind; behind this the lining brickwork, which at many points had been disrupted and pushed into the furnace, showed signs of excessive carbon deposition and the softening of the brick. By the 15th day, all the necessary brickwork had been removed, the heavy scaffold lumps being removed through the furnace top. Then a steel frame was installed at tuyere level to carry the big bell together with the supports for the solid bricklayers' scaffold located some 18 in. below the mantle. Figure 6 shows the bell supported at tuyere level.

The inwall lining commenced at the mantle with a footing on the top row of bosh plates for the working face course. Finishing the new brickwork at the underside of the stockline was very important, and again, every effort was made to ensure that no settlement of the stockline section ensued when the supports were released. When the bricklayers were within two feet of the supporting stringers, the intermediate H-beams and timber struts were removed and the brickwork built up

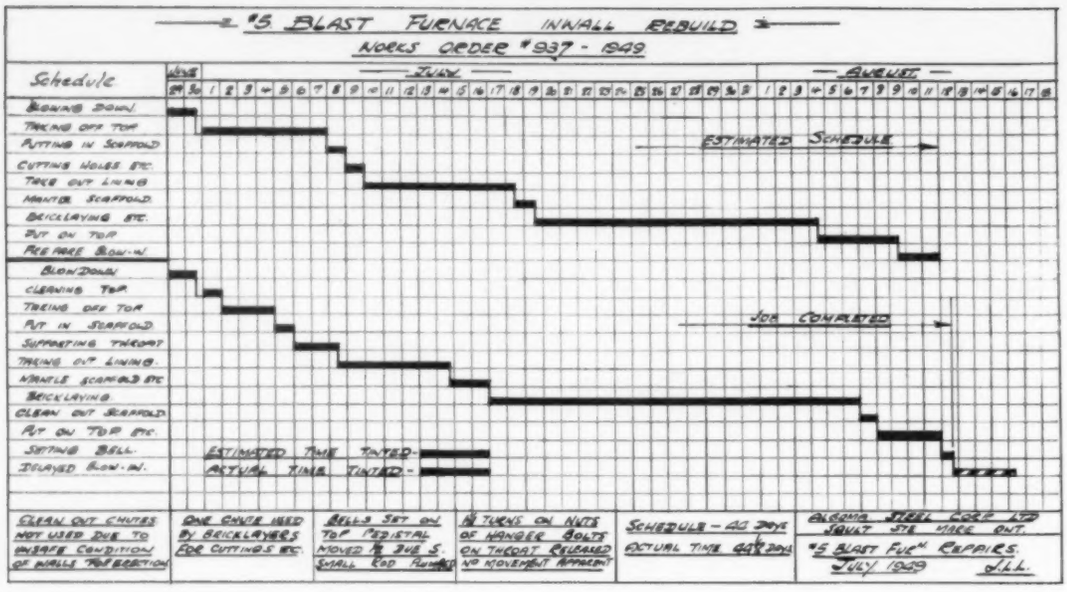


Figure 8 — The actual job time followed the estimated time very closely.

in these sections to the bottom row of throat wearing plates — the last course being ground and driven tight, so that all that eventually remained were the 12 holes through which were located the 12 stringers. The U-bolts on the top channel grill were then carefully eased off, a quarter of a turn at a time all round the 24 nuts, while a very close watch was maintained on the stockline section. The whole ring was loose at 1¼ turns on each nut, and no settlement was apparent. Another glance at Figure 2 will indicate that about 3/16 in., which is equivalent to 1¼ turns on the nuts employed, could be accounted for by stretch on a tie rod 19-ft long with an offset just below the hopper face.

The supporting steel was then quickly removed and the holes left by the stringers built up and driven again on the last course. Replacement of furnace top equipment followed.

At this point, it should be mentioned that for cleaning out the lining of the furnace, we had intended to employ tube chutes, as shown in Figure 7. These tubes were 20 in. diameter, made up in 4 foot lengths, and had suitable quick joint fixing attachments. These were to have been set up, discharging through two tuyere ports into another chute spread to either side of the cast house and discharging into ladles. However, due to the state of inwall lining and the scaffolded condition, it was not thought safe for men to work in the furnace hearth erecting the necessary steelwork to carry both the big bell and the chutes. One tube, however, was employed during relining to clear away brick cuttings and debris from the bricklayers scaffolds, and this proved of advantage. Such tube chutes might well prove of advantage on a normal cleanout, where the program did not call for any ripping out below the mantle; whilst time might not be saved in the actual tearing out of the lining, there would be a definite saving of labour and time in clearing bricks and debris from the hearth.

The furnace was ready in 44 days as scheduled, everything going according to plan with the exception of the bricklaying which was interrupted on two occasions as previously mentioned. Figure 8 shows a graph, the top line of which represents the scheduled and the bottom the actual time taken on the various jobs.

Considerable general repair work was done during the time the furnace was down, included in which was a complete overhaul of the distributor which called for the fitting of new side rollers; since these have been installed, side play on the distributor under operating conditions has been reduced to a minimum, thus allowing gland packing to be maintained tight. Prior to the installation of these side rollers, this had been a source of trouble on this furnace, the gland having been repacked on various occasions since the furnace commenced operation in 1943.

Since the time the inwall lining was renewed on this furnace, production on the new inwall lining now standing at 487,908 net tons as against 2,340,318 net tons for the hearth and bosh, various opportunities have been taken to inspect the stockline section through open bells. Such inspection has shown that the stockline and stockline wearing plates are in excellent shape; in addition, these examinations have shown that the brickwork immediately below the throat wearing plates, a sector also of importance in stockline distribution, is in good shape, showing that the jointing of the new inwall to the suspended stockline was effectively accomplished.

DISCUSSION

PRESENTED BY

W. J. SCHARFENAKER, Ford Motor Co., Dearborn, Mich.

D. JOYCE, Assistant Superintendent of Blast Furnaces, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada.

W. J. Scharfenaker: How many days operating time did you save?

D. Joyce: The record shows we saved about $50,000 by leaving the stockline section in. And with the men thus made available we probably saved about another ten days in actual rebricking time. Had we taken the whole stock section out, it would have been ten days longer.

HARD FACING ALLOYS FOR STEEL MILL USE

By HOWARD S. AVERY
Research Metallurgist
American Brake Shoe Co.
Mahwah, N. J.

. . . . this paper sets up a pattern which may be used to select hard facing alloys which will perform satisfactorily in steel mill applications . . . .

▲ HARD facing is a widely accepted technique in steel mill maintenance practice and usually needs no introduction to those charged with economy and efficiency in operations. Perhaps the most disconcerting aspect of using hard facing is the confusion that may develop in selecting suitable alloys, since few of them are described in the engineering terms that characterize our use of steels. This paper will attempt to clarify this area by classifying the types and describing some of the properties. It will suggest how the material can be selected by using judgment based on an analysis of service factors.

Hard facing is a versatile weapon for controlling wear. In comparison with homogeneous metallic parts it usually has the advantage of applicability to the exact area where wear is focused, ready use of very hard and wear resistant compounds, ease of application outside of manufacturing plants, economy in the effective use of expensive alloying elements, and protection in depth. This last is particularly important in comparison with other surface protection methods such as carburizing, electro plating and the like.

Wear is usually a complex end product of many factors. It is defined as deterioration due to use and is generally a surface phenomenon. The more obvious factors can be classified as impact, heat, corrosion, friction, abrasion and vibration. Five of these can be subdivided into more precise factors and materials can be selected for optimum performance when one element of wear is clearly dominant. The sixth factor, vibration, is the cause of mechanical fatigue failures and is usually dealt with by refinements in design that minimize or avoid stress concentrations.

The first step in bringing order to the hard facing field is classification of the available types. This has not been easy, with the result that early classifications are oversimplified and frequently misleading. An example of this was the grouping into low and high alloy classes, with the implication that merit or wear resist-

Figure 1 — Relative abrasion resistance vs. total alloy content. This illustrates the fallacy of assuming that alloy content regardless of structure is a reliable criterion for judging wet sand abrasion resistance.

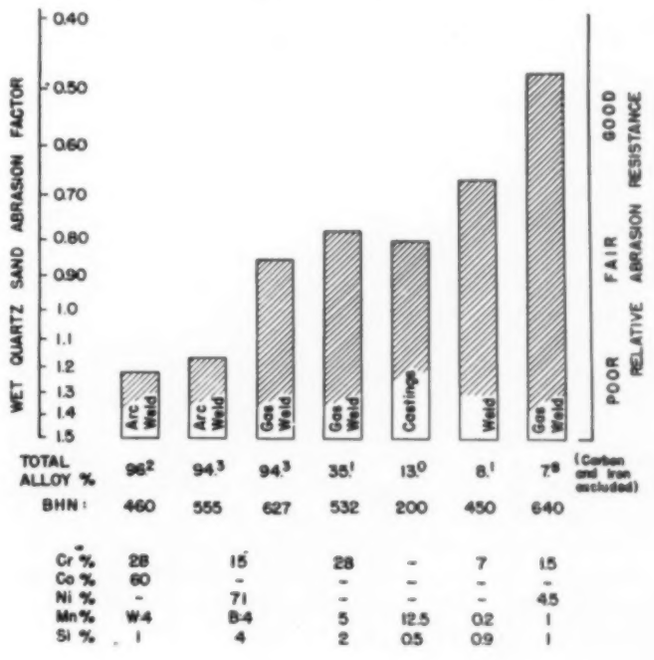


TABLE I

CLASSIFICATION OF HARD FACING ALLOYS

BY CHEMICAL COMPOSITION

AWS Class	Description	C, per cent	Cr, per cent	Other elements, per cent
I	Ferrous alloys			
IA	Hardenable alloys			
I-A-1-	Carbon steels			
a.	Low	0.19 max	.....	(Refer to AWS Spec. A5.1-48T)
b.	Medium	0.20-0.60	.....	1 maximum
c.	High	0.61 min	.....	1 maximum
I-A-2-	Low alloy grades			
a.	Low carbon	0.19 max	.....	(Refer to AWS Spec. A5.5-48T)
b.	Medium carbon	0.20-0.60	.....	0.4-6.0
c.	High carbon	0.61-1.50	.....	0.4-6.0
d.	Cast iron types	1.50 min	.....	0.4-6.0
I-A-3-	Medium alloy grades			
a.	Medium carbon	0.21-0.60	4-10	6-12 including chromium
b.	High carbon	0.61-1.70	4-10	6-12 including chromium
c.	Cast iron types	1.70 min	4-10	6-12 including chromium
I-A-4-	High alloy grades			
a.	Low carbon	0.20 max	10-14	12-30 including chromium
b.	Medium carbon	0.21-0.50	10-14	12-30 including chromium
c.	High carbon	0.51-2.5	10-14	12-30 including chromium
d.	Cast iron types	2.50 min	10-14	12-30 including chromium
I-A-5-	High speed steels	0.61 min	2-6	Tungsten and/or Mo
IB	Austenitic steels			
I-B-1-	Chromium and Cr-Ni grades			
a.	Low carbon	.....	.....	(Refer to AWS Spec. A5.4-48T)
b.	High carbon, low nickel	0.20-1.70	4.0 min	4 maximum
c.	High carbon, high nickel	0.20-1.70	15.0 min	4 maximum; except for 7.0-Ni min
I-B-2-	High manganese			
a.	Nickel-manganese type	0.70 min	.....	Minima of 3.5 Ni & 12.0 Mn
b.	Moly-manganese type	0.60 min	.....	Minima of 1.0 Mo & 11.0 Mn
IC	Austenitic irons — not usually heat treated			
I-C-1	High chromium iron	2.0 min	22.0 min	.....
I-C-2-	High alloy irons			
a.	Medium carbon	1.7 min	4-10	6-12 including chromium
b.	High carbon	2.5 min	10-14	12-30 including chromium
c.	Very high alloy	2.5 min	.....	Minimum of 40 iron
IIA	Cobalt base — medium carbon	.....	24.0 min	40 Co min 3.5 W min
IIB	Cobalt base — high carbon	.....	24.0 min	40 Co min 10.0 W min
IIIA	Tungsten carbide inserts	.....	.....	.....
IIIB	Composite tungsten carbide	1.8 min	.....	.....
IIIC	Tungsten carbide powder	.....	.....	.....
IVA	Copper-zinc alloys (brasses)	.....	.....	.....
IVB	Copper-silicon bronzes	.....	.....	85 Cu min 5.0 Si max
IVC	Copper-aluminum bronzes	.....	.....	80 Cu min 8.0 Al min
VA	Nickel-copper alloys	.....	.....	2-30 Ni, 70-98 Cu
VB	Nickel-chromium alloys	.....	.....	.....
VC	Nickel base, Cr-W-Mo alloys	.....	.....	.....

ance was related to alloy content. The fallacy of this is shown in Figure 1 where results from one standardized abrasion test are plotted against total alloy content, excluding iron and carbon. The apparent trend, opposite to that of the early classification implication, is not valid either. The data are reliable, but if many more materials are added to the graph the trend disappears, demonstrating that alloy content, per se, is not a valid criterion.

A classification system cannot well provide an index to performance, nor can one type of wear test rank materials for all applications. The Cr-Co-W alloy in Figure 1, while showing poor resistance to grinding abrasion, is outstanding for hot wear service as typified by valve facings. A chemical classification merely provides a logical pattern for identifying and listing available materials, and must be supplemented by structural typing and much specific detail before wise selections for use can be made.

Several years ago an American Welding Society—ASTM Committee spent considerable effort on a chemical classification. This was included in the latest (1950) edition of the Welding Handbook. It is reproduced here in modified form. (Table I).

Engineers in the steel industry are likely to be familiar with the low and medium carbon steels listed in Table I, but the cast iron types, some of the non-ferrous alloys and the composites are not well known. The list is too long to attract the study that is required for efficient hard facing alloy selection, and moreover, some of the important properties are more directly related to structure than to chemistry.

Metallurgical research has generally established that the constitution and structure of metals are fundamental factors that determine their properties. The science of metallography or physical metallurgy has developed around this trend. Composition, as determined by chemical analysis, is important and may be

TABLE II

A GRADED SERIES OF WEAR RESISTANT ALLOYS

Increasing abrasion resistance ↑ / Increasing toughness ↓

Properties sensitive to carbon content and structure

1. Tungsten carbide composites	Maximum abrasion resistance. Worn surfaces become rough.
2. High chromium irons	Excellent erosion resistance. Oxidation resistance.
3. Martensitic irons	Excellent abrasion resistance. High compressive strength.
4. Cobalt base alloys	Oxidation resistance. Corrosion resistance. Hot strength and creep resistance.
5. Nickel base alloys	Corrosion resistance. May have oxidation and creep resistance.
6. Martensitic steels	Good combinations of abrasion and impact resistance. Good compressive strength.
7. Pearlitic steels	Inexpensive. Fair abrasion and impact resistance.
8. Austenitic steels Stainless steels Manganese steel	Work hardening. Corrosion resistance. Maximum toughness with fair abrasion resistance. Good metal to metal wear resistance under impact.

decisive in the production of a desired structure with its attendant properties, but other factors, such as heat treatment, may be more influential. It is also possible to produce a required structure with several different compositions or to produce several structures by different treatments of the same alloy. For these reasons, it is desirable to classify hard surfacing deposits in terms of structure where possible.

Combining both chemistry and structure, the simplified classification of Table II has been arranged. This reduces the number of types to a manageable group that will serve for probably 90 per cent or more of steel mill applications. Each of these will be described in some detail and their properties summarized. There are of course borderline or transitional grades that do not fall nicely into this list. Moreover, some alloys could appear in two places, since it is possible to have a high-chromium iron that is martensitic or a composite carbide weld deposit that is actually a martensitic steel. However, these will be noted in the discussion where practicable. Compromises are necessary in the interests of simplification and the reduction in types needed for steel mill use will probably be welcomed by those concerned with inventories.

TUNGSTEN CARBIDE COMPOSITES

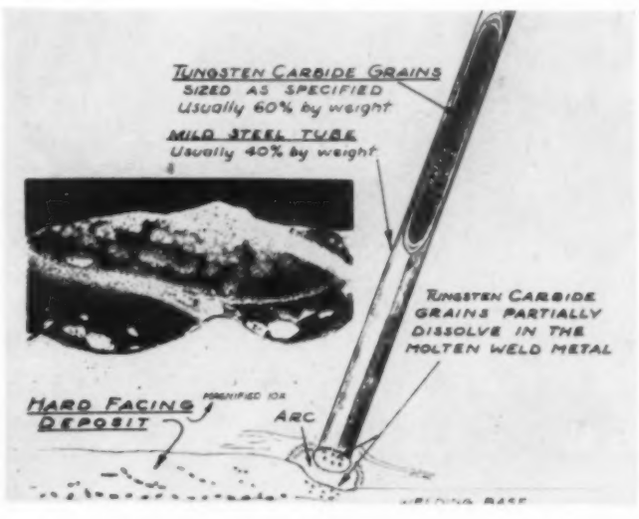
Tungsten carbide is commercially available as sintered compacts produced by powder metallurgy (tool tips are a familiar example), as cast slugs or inserts, as granules produced by crushing cast materials, and as a component of composite welding rods.

The commonest composite rod is a tube of mild steel filled with granulated carbide. Small proportions of other materials, such as arc stabilizers, binders and the like may be included. Different percentages of steel and filler are employed for some applications. These may be obtained by variations of tube thickness or by inclusion of iron powder in the filler. The latter is especially suitable if a low proportion of carbide granules is wanted.

Most of the commercial rods are standardized on about 60 per cent filler and 40 per cent sheath, by weight. Either coarse or fine granules may be obtained, and rods are available with 5-8, 8-10, 10-20, 20-30, 30-40, and -40 mesh sizes. A designation such as 30-40 indicates that the sized material will pass a 30 mesh screen but be retained on a 40 mesh screen.

The rods may be used either bare or coated as electrodes for arc deposition. Gas welding is done with bare rods. If care is used, and the metallurgical changes produced by welding are held within reasonable limits, the deposits from such composite rods (Figure 2) provide an outstanding level of abrasion resistance for hard facing use. The sheath tubing melts during welding and dissolves both tungsten and carbon to form a hard

Figure 2 — The deposited metal consists of tungsten carbide granules scattered through a matrix of tungsten steel or iron, depending on carbon oxidation and dilution.



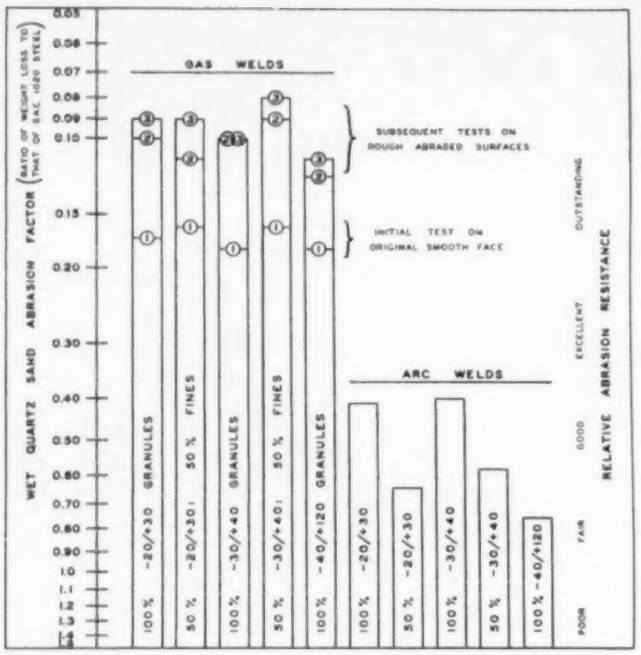


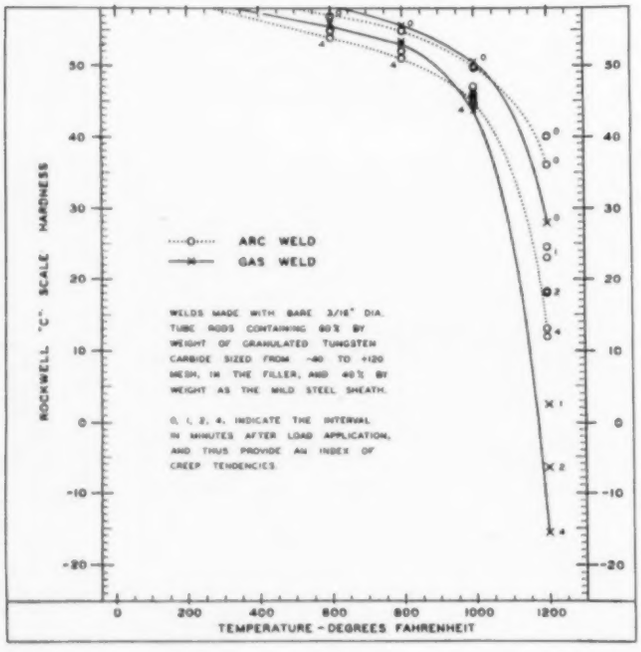
Figure 3 — Abrasion resistance of composite tungsten carbide weld deposits are affected by granule size and welding method.

matrix that anchors the very hard granules in place. Instead of being a mild steel binder for the tungsten carbide as is sometimes believed, this matrix has characteristics that range from those of tungsten steel to cast iron structures containing considerable secondary tungsten-iron carbides.[1]*

Surface roughness of abraded deposits depends on initial granule size and welding procedures. Abrasion resistance depends largely on the volume of undissolved carbides, and is generally better for gas welds.

* References refer to Bibliography at end of paper.

Figure 4 — The effect of temperature on apparent hot hardness.


ROCKWELL "C" SCALE HARDNESS
ARC WELD
GAS WELD
WELDS MADE WITH BARE 3/16" DIA. TUBE RODS CONTAINING 60% BY WEIGHT OF GRANULATED TUNGSTEN CARBIDE SIZED FROM -60 TO +120 MESH, IN THE FILLER, AND 40% BY WEIGHT AS THE MILD STEEL SHEATH.
0, 1, 2, 4, INDICATE THE INTERVAL IN MINUTES AFTER LOAD APPLICATION, AND THUS PROVIDE AN INDEX OF CREEP TENDENCIES.
TEMPERATURE - DEGREES FAHRENHEIT

However, the hot hardness of arc welds is higher at 1200 F. The Vickers micro hardness of the primary tungsten carbide is about 2400 VPN (25 gm load), while the secondary carbide, $(Fe,W)_6C$, is near 1750 and the other matrix constituents are softer. Arc welding may largely dissolve the primary carbides, especially if they are very fine, and result in loss of their distinctive abrasion resistance. These relations are illustrated graphically in Figures 3 and 4 to aid the user of hard facings in evaluating performance.

Figure 5 illustrates the range in structures that can be encountered. The extreme case, where the fine tungsten carbides have been dissolved to produce a tungsten steel, can be avoided by proper selection of material and welding technique. A more extended discussion of this hard facing material is available elsewhere.[1]

HIGH CHROMIUM IRONS

If several per cent of carbon is combined in an alloy with about 25 per cent chromium, hard crystals of the trigonal carbide, Cr_7C_3, will be produced. This also leads to a composite structure but unlike tungsten carbide, the compound crystalizes from the molten weld deposit. The rods or electrodes are usually cast and homogeneous in composition. (Table III).

The accessory alloying elements are typically about 6 per cent manganese and 2 per cent silicon. This combination produces good welding behavior. The matrix is austenitic, though it is harder than most low carbon austenites, such as those of the stainless steels.

The level of 25 per cent or more of chromium confers good oxidation resistance. The hard carbides provide excellent erosion resistance, though they may fail from fracture if high stresses are imposed. This alloy has found wide acceptance for facing plow shares that work in sandy soil. In steel mills it also can serve where loose abrasive materials are handled. It is not recommended where resistance to high stress grinding abrasion or high elastic compressive strength are needed.

Hot hardness characteristics appear in Figure 6.

If composition is suitably adjusted, the high chromium irons may exhibit either a pearlitic or a martensitic matrix. Such alloys are more frequently used as casting than as welding rods. However, they can be deposited, and when the composition is carefully balanced they can be softened for machining and subsequently rehardened. The austenitic high chromium irons are considered unmachinable and are finished by grinding if precise dimensions are required.

MARTENSITIC IRONS

Cast iron (implying an alloy with above 2 per cent carbon) is ordinarily pearlitic; that is it consists of a mixture of pearlite and either iron carbide or graphite. Composition and cooling rate factors determine whether the iron will have its excess carbon in the form of soft flakes or nodules of graphite (grey cast iron) or in the shape of a network and masses of cementite or iron carbide (white cast iron). The fracture of graphitic irons is characteristically black or dark grey, while iron

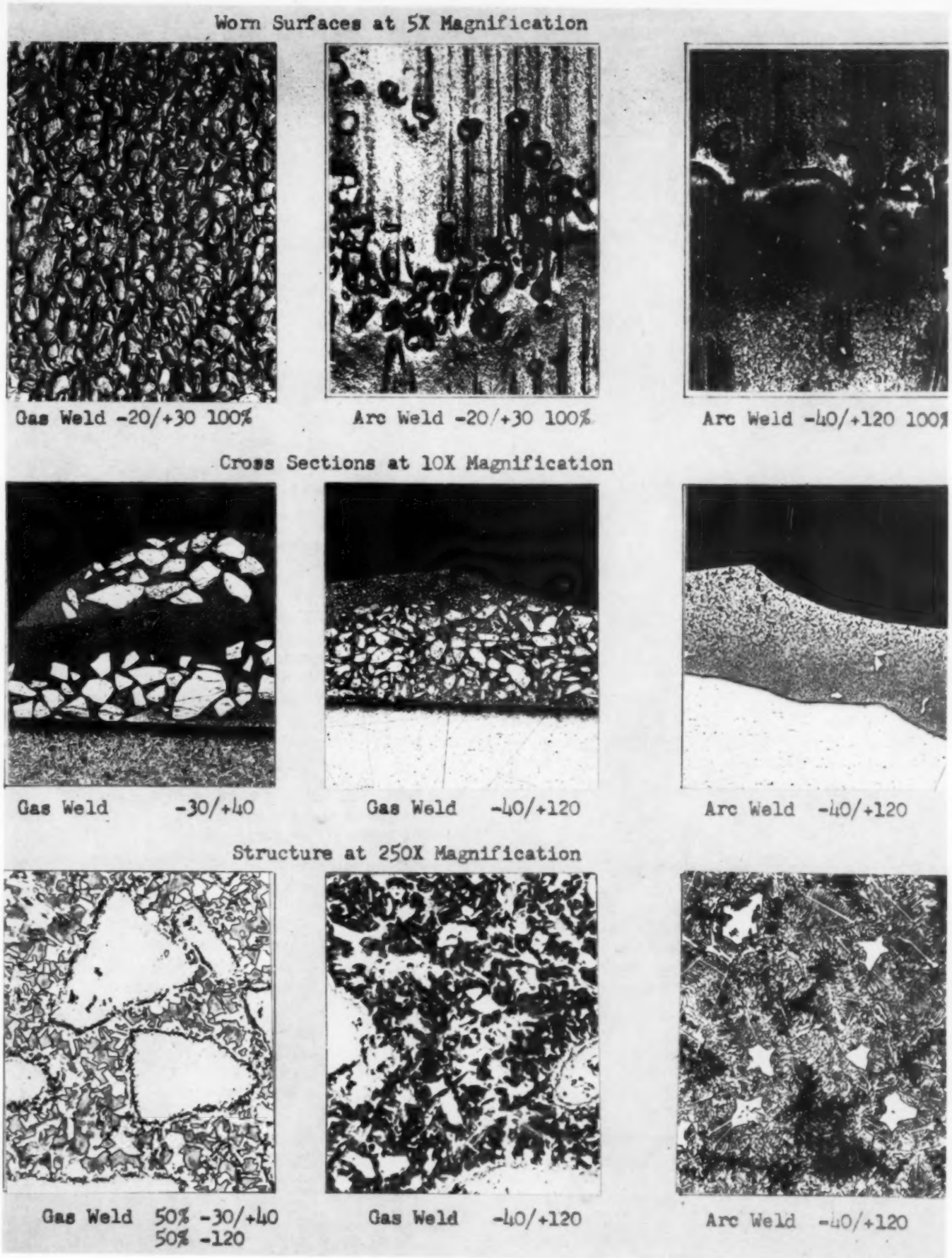


Figure 5 — Structure of composite tungsten carbide welds are shown in these graphs.

carbide gives a bright and silvery surface. Borderline structures containing both graphite and iron carbide are mottled in appearance. Cast irons usually contain several per cent of carbon, the excess above perhaps 0.90 per cent operating to confer brittleness. (Actually the dividing line between steels and cast irons is about 1.7 per cent carbon, but usually with slow cooling the cementite network and its attendant brittleness develop above 0.90 per cent carbon.)

Note that the constituent containing about 0.90 per cent carbon, which is associated with either cementite or graphite, corresponds to steel in behavior and properties. It is softer and tougher than iron carbide, and it can be modified by heat treatment. It ordinarily appears as the lamellar mixture of ferrite (or soft iron) and cementite that we recognize as pearlite and which has a hardness of from 200 to 400 Brinell. The associated carbide is near 1300 VPN.* Thus the structure of

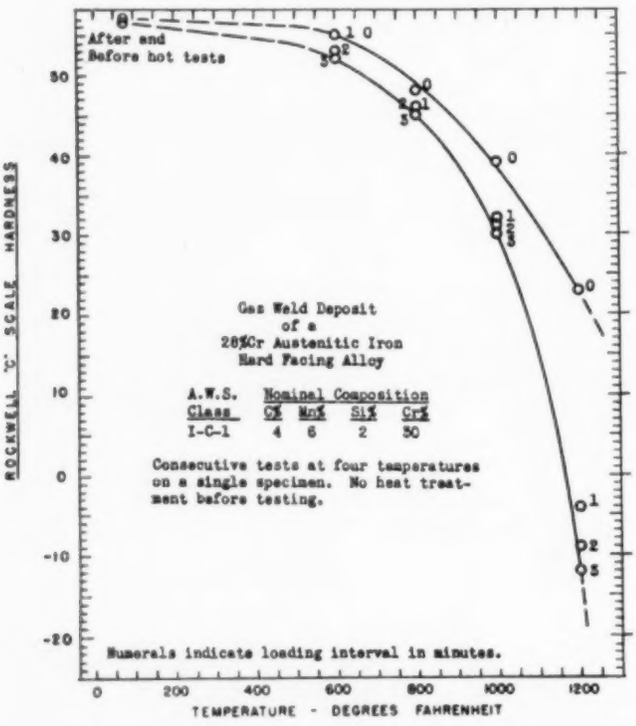

After and
Before hot tests
Gas Weld Deposit
of a
28%Cr Austenitic Iron
Hard Facing Alloy
A.W.S. Class I-C-1
Nominal Composition C% 4 Mn% 6 Si% 2 Cr% 30
Consecutive tests at four temperatures on a single specimen. No heat treatment before testing.
Numerals indicate loading interval in minutes.
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

Figure 6 — Hot hardness of an austenitic gas weld deposit from a 28 per cent chromium iron. The effect of tempering during the test run was negligible.

white iron contains two constituents that differ greatly in hardness.

Pearlitic white iron may be used in the form of castings, as the chilled face of a grey iron casting (rapid cooling can prevent graphitization) or as a weld deposit. The first two are common. Pearlitic iron weld deposits are also encountered, but performance is so improved by inducing a martensitic structure that it is generally uneconomical not to do so.

The steel portion of a cast iron composition can, like steel, be hardened by quenching properly. For weld

* Brinell hardness numbers (BHN) are not suitable for use with very hard compounds. Consequently Vickers pyramid numbers (VPN) corresponding mathematically to Brinell values but obtained with a diamond pyramid instead of a steel ball, will be occasionally used herein.

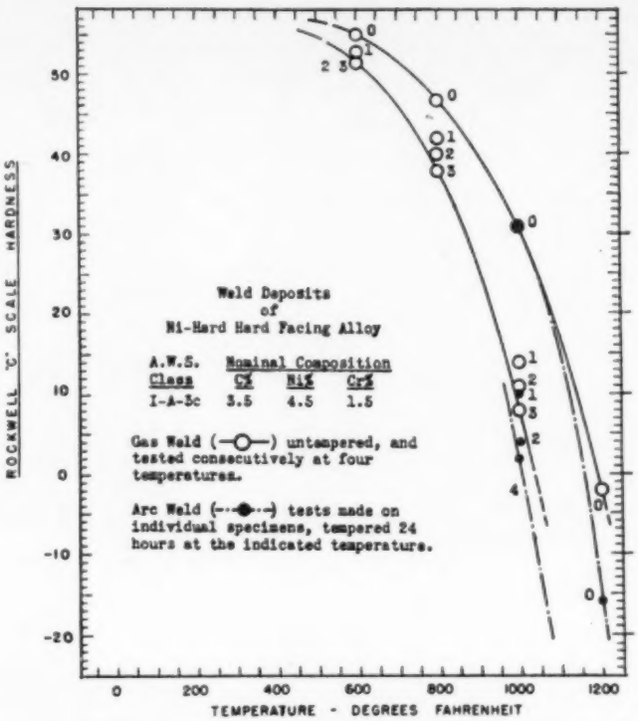

Weld Deposits
of
Ni-Hard Hard Facing Alloy
A.W.S. Class I-A-3c
Nominal Composition C% 3.5 Ni% 4.5 Cr% 1.5
Gas Weld (—○—) untempered, and tested consecutively at four temperatures.
Arc Weld (---●---) tests made on individual specimens, tempered 24 hours at the indicated temperature.
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

Figure 7 — Hot hardness of weld deposits from a nickel-chromium martensitic iron.

deposits this is not always possible, and moreover it sacrifices much of the simplicity of hard facing. It is better to add alloying elements that will cause the martensitic hardening transformation to occur during normal cooling of a weld. With adequate metallurgical skill and production control this can be done with a number of compositions. These martensitic irons, used

Figure 8 — Hot hardness of gas weld deposits from martensitic Cr-Mo iron; tested with and without tempering before determining hardness.

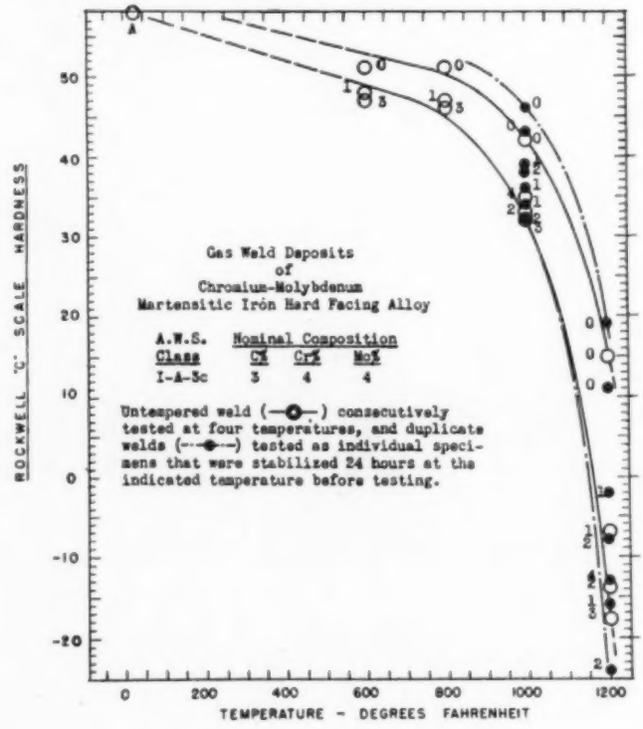

Gas Weld Deposits
of
Chromium-Molybdenum
Martensitic Iron Hard Facing Alloy
A.W.S. Class I-A-3c
Nominal Composition C% 3 Cr% 4 Mo% 4
Untempered weld (—○—) consecutively tested at four temperatures, and duplicate welds (---●---) tested as individual specimens that were stabilized 24 hours at the indicated temperature before testing.
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

TABLE III

PROPERTIES OF AUSTENITIC HIGH CHROMIUM IRON

Type composition	Oxy-acetylene gas welded	Small castings*	Electric arc welded
	Chemical analysis, per cent		
	C	Mn	Si	Cr
	4.0-5.0	6	2	25-30
Resistance to flow under repeated impact	Excellent	Excellent	Good
Tensile toughness	Low	Low	Low
Resistance to cracking under repeated impact	Low	Low	.....
Oxidation resistance	Excellent	Excellent	Excellent
Maximum temperature considered advisable	2000 F	2000 F	2000 F
Creep resistance	Fair	Fair	Fair
Rockwell hardness at 70 F	C50-58	C57	C50-C58
600 F	C55	C50	.....
800 F	C48	C47	.....
1000 F	C39-C40	C36	C37
1200 F	C23-C25	.....	C6
Compression strength:			
0.10 per cent set yield — psi	86-122000		
Ultimate — psi	152-287000		
Elastic deformation — per cent	0.7-1.1		
Plastic deformation — per cent	0.4-3.4		
Abrasion resistance	Fair	Fair	Fair
Wet sand abrasion factor	0.67	0.88	0.74
Erosion resistance	Excellent	Excellent	Excellent
Dry sand erosion factor	0.04-0.07	.....	.....

*Properties considered between those of gas and electric weld deposits.
Used for some test specimens to eliminate welding variables and defects.
*Properties considered between those of gas and electric weld deposits. Used for some test specimens to eliminate welding variables and defects

TABLE IV

PROPERTIES OF SOME MARTENSITIC IRONS

	Chrome-nickel type			Chrome-molybdenum type			Chrome-tungsten type		
	Gas welded	Small castings*	Arc welded	Gas welded	Small castings*	Arc welded	Gas welded	Small castings*	Arc welded
Type composition	4.5 per cent Ni 1.5 per cent Cr			4 per cent Cr 4 per cent Mo			8 per cent Cr 15 per cent W		
Resistance to flow under repeated impact	Good			Good			Excellent		
Tensile toughness	Low			Low			Low		
Resistance to cracking under repeated impact	Low			Fair			Fair		
Oxidation resistance	Low			Low			Medium		
Maximum temperature considered advisable	1000 F			1100 F			1200 F		
Creep resistance	Low			Fair			Fair		
Rockwell hardness at 70 F	C60	.....	C64	C63	.....	C57	C62	.....	C65
600 F	C51	C48	.....	C51-54	.....	.....	.....	.....	.....
800 F	C51	C42	.....	C52	.....	.....	.....	.....	.....
1000 F	C27	C17	C42	C46-43	.....	C43	C50	.....	C51
1200 F	C-13	.....	C-8	C19-7	.....	C4	C32	.....	C27
Compression strength:									
0.10 per cent set yield — psi	180000			150000-285000			176000-226000		
Ultimate — psi	260-380000			265000-386000			292000-384000		
Elastic deformation — per cent	0.9-1.6			1.2-1.4			0.9-1.0		
Plastic deformation — per cent	0.6-3.0			0.3-1.4			0.3-0.5		
Abrasion resistance	Good	Good	Fair	Excellent	Excellent	Good	Excellent	.....	Good
Wet sand abrasion factor	0.37/0.57	0.30/0.65	0.60/0.74	0.30/0.46	0.34/0.47	0.38/0.54	0.28/0.50	.....	0.40/0.60
Erosion resistance	Good	.....	Fair	Excellent	.....	Good	Excellent	.....	Good
Tensile strength — psi	22000-43000	.....	.....	.....	.....	.....	.....	.....	.....
Elongation — per cent	0.001-0.050	.....	.....	.....	.....	.....	.....	.....	.....
Brinell hardness	500-650	.....	.....	.....	.....	.....	.....	.....	.....

*Properties considered between those of gas and electric weld deposits. Used for some test specimens to eliminate welding variables and defects.

either as hard facing alloys or as castings have built up an enviable reputation for wear resistance. Under severe grinding abrasion they will usually out wear pearlitic irons by a ratio of 2 or 3 to 1.

Their martensitic areas have a hardness of 500 to 700 BHN, and are thus nearer that of the associated iron carbide. This is probably important in relation to abrasion because it has been noted that structures containing soft and very hard constituents together are likely to abrade rapidly. This is possibly due to undermining of the hard portion, because the soft material wears so much more rapidly. Whatever the mechanism, the good abrasion resistance of martensitic irons has been well established.

It requires more metallurgical know-how to produce martensitic irons than for many other hard facing alloys. However, the effort is justified because several valuable properties can be obtained in combustion. High compression strength is an asset for these alloys. It helps avoid seizing and galling in metal to metal frictional wear and it provides surprisingly good impact resistance if the hard overlay is adequately supported. Repeated blows can be sustained indefinitely if they produce compressive stresses below the elastic limit of the hard facing. Where cracking occurs under conditions where shear is carefully avoided, it will usually be found that base deformation under the weld has permitted tension to develop in it. These alloys are too brittle to withstand tensile stresses over perhaps 60,000-80,000 psi, but their ultimate compressive strength may approach 400,000 psi.

The resistance of martensitic irons to erosion, or low stress abrasion is generally inferior to that of the austenitic high chromium iron, but they are superior to the latter under high stress abrasion. Their hot hardness depends largely on the alloy combination used to develop the martensitic structure. Three different grades, using chromium and nickel, chromium and molybdenum, and chromium with tungsten respectively are shown in Figures 7, 8, and 9. The chromium-tungsten type has a high level of erosion resistance, abrasion resistance, elastic compressive strength and hot hardness, especially in gas weld deposits. Where its brittleness is not objectionable (that is where tension can be avoided) it merits primary consideration when high all around performance is desired. Properties of these alloys are summarized in Table IV.

TABLE V

HOT HARDNESS SURVEY OF COBALT BASE ALLOYS

A.W.S. Class II-A

Usual commercial designation: No. 6

Nominal per cent composition: 1.0 C, 28 Cr, 4.5 W, Balance Cobalt.

Specimen	Rockwell "C" scale hardness									
	75 F		600 F		800 F		1000 F		1200 F	
	B.	A.	0	3	0	3	0	3	0	3
Gas weld	47	45	37	37	35	35	31	30	25	17
Arc weld	45	45	37	37	35	34	31	30	27	26
Gas weld	44	44	.....	.....	34	33	31	30	27	25
Gas weld	41	42	.....	.....	31	30	27	26	21	14
Casting (st)	40	40	.....	.....	.....	.....	28	26	22	16
Average	43	43	37	37	34	33	30	28	24	20

A.W.S. Class II-A

Usual commercial designation: No. 1

Nominal per cent composition: 2.5 C, 31 Cr, 12.5 W, Balance Cobalt.

Specimen	Rockwell "C" scale hardness									
	75 F		600 F		800 F		1000 F		1200 F	
	B.	A.	0	3	0	3	0	3	0	3
Arc weld	59	59	53	51	50	48	47	47	36	24
Gas weld	57	55	50	49	47	46	45	44	37	30
Gas weld	53	53	.....	.....	47	46	44	43	44	42
Gas weld	55	56	.....	.....	48	47	46	45	42	40
Gas weld (st)	54	54	.....	.....	.....	.....	45	43	40	32
Arc weld (st)	51	51	.....	.....	.....	.....	35	32	35	23
Casting (st)	55	54	.....	.....	.....	.....	45	43	41	35
Average	55	55	52	50	48	47	44	43	39	32

Code: B. = before hot testing. A. = after testing at 1200 F.
0 and 3 indicate the interval in minutes after load application.
(st) indicates that individual specimens were stabilized by tempering 24 hours at the test temperature before testing.

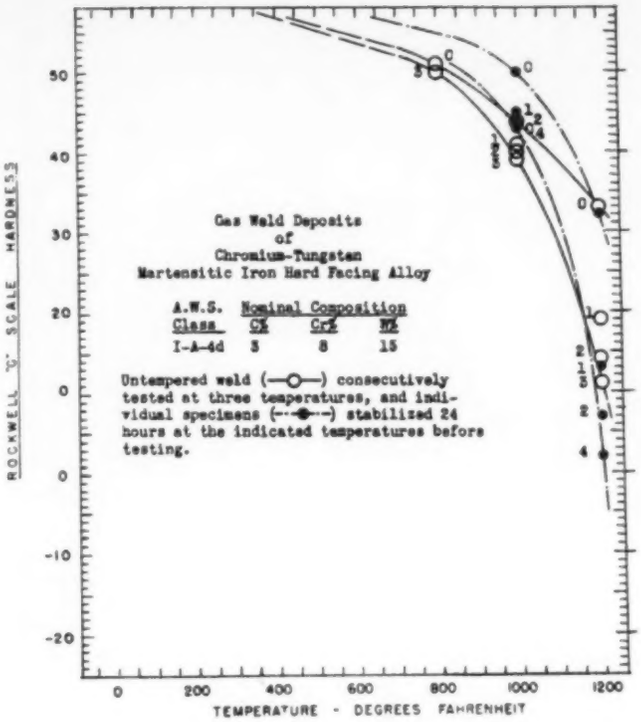

Gas Weld Deposits
of
Chromium-Tungsten
Martensitic Iron Hard Facing Alloy
A.W.S. Class I-A-4d
Nominal Composition C% 3 Cr% 8 W% 15
Untempered weld (—O—) consecutively tested at three temperatures, and individual specimens (---●---) stabilized 24 hours at the indicated temperatures before testing.
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

Figure 9 — Hot hardness of gas weld deposits from martensitic Cr-W iron; tested with and without tempering before determining hardness.

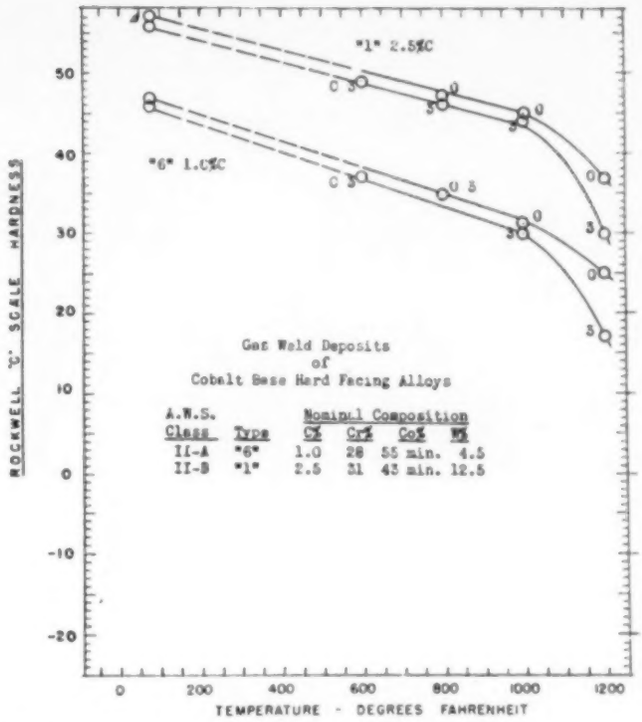

"1" 2.5%C
"6" 1.0%C
Gas Weld Deposits
of
Cobalt Base Hard Facing Alloys
A.W.S. Class Type Nominal Composition C% Cr% Co% W%
II-A "6" 1.0 28 55 min. 4.5
II-B "1" 2.5 31 43 min. 12.5
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

Figure 10 — Hot hardness of gas welded overlays from industrially standardized cobalt base alloys. Successive tests at four temperatures on one untempered specimen of each type.

COBALT BASE ALLOYS

The outstanding materials for hot strength above 1200 F are cobalt base alloys containing 25 per cent or more of chromium, several per cent of tungsten and from 0.5 to 3.0 per cent carbon.

The most popular variations are:

A.W.S. Class	Usual commercial designation	Nominal composition, per cent			
		C	Cr	W	Co
IIA	"6"	1.0	28	4.5	55 min
IIB	"1"	2.5	31	12.5	43 min

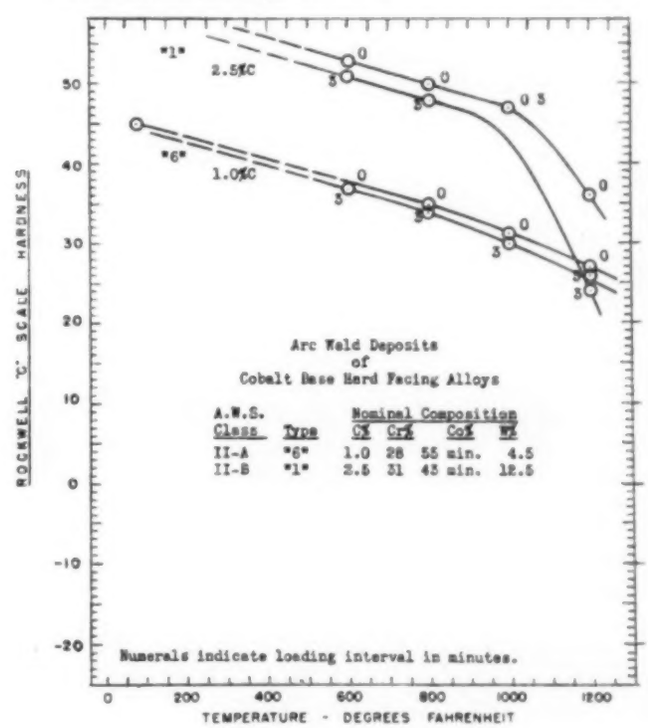
These are merely two points in an extensive system of alloys that covers a wide range in properties, but they have been rather well standardized by a number of manufacturers and they represent focal points of considerable field experience.

At one end of the series that has received industrial attention is the X-40 alloy of the Office of Scientific Research and Development program directed toward improved gas turbine alloys. This material in the form of castings (NR No. 71 composed of following percentages—0.5 C, 0.6 Mn, 0.7 Si, 25 Cr, 10 Ni, 55 Co, 7 W, 0.6 Fe) was about the strongest material at 1800 F of the many machinable alloys included in this wartime research effort in which many laboratories participated.

At room temperature, the hardness of the 0.5 per cent C alloy is near 300 Brinell. At 1.0 per cent carbon it approximates 400 BHN and at 2.5 per cent C it is seldom under 500 BHN. Hot hardness follows much the same pattern, with zero time values of Rockwell C27-C31 for 1 per cent C and C35-C47 for 2.5 per cent C at 1000 F; C21-C27 for 1 per cent C and C35-C44 for 2.5 per cent C at 1200 F. Carbon is thus a potent minor component.

Note that these hardness values at 1200 F are rela-

Figure 11 — Hot hardness of arc welded overlays from industrially standardized cobalt base alloys. Successive tests at four temperatures on one untempered specimen of each type.


"1" 2.5%C
"6" 1.0%C
Arc Weld Deposits
of
Cobalt Base Hard Facing Alloys
A.W.S. Class Type Nominal Composition C% Cr% Co% W%
II-A "6" 1.0 28 55 min. 4.5
II-B "1" 2.5 31 43 min. 12.5
Numerals indicate loading interval in minutes.
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

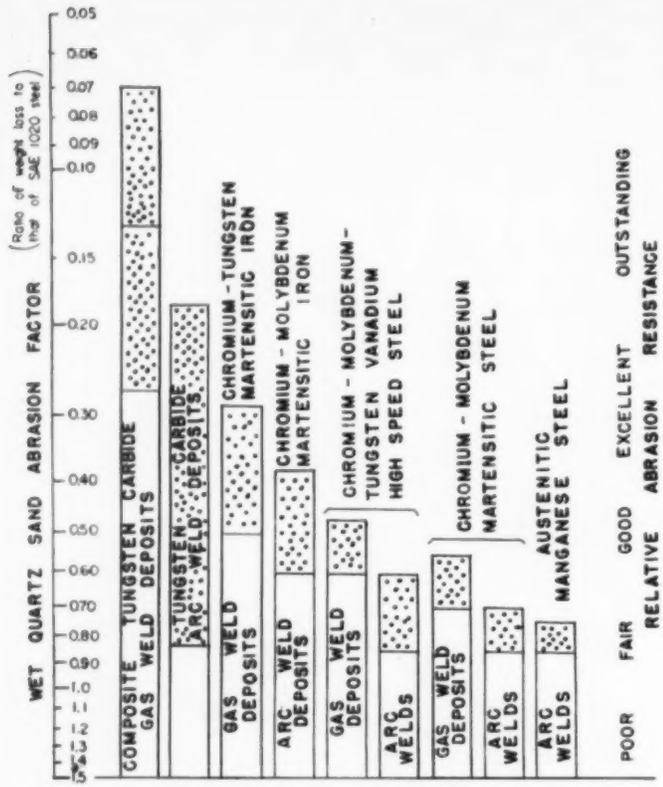


Figure 12 — Abrasion resistance of some martensitic alloys. Stippled areas indicate observed scatter bands.

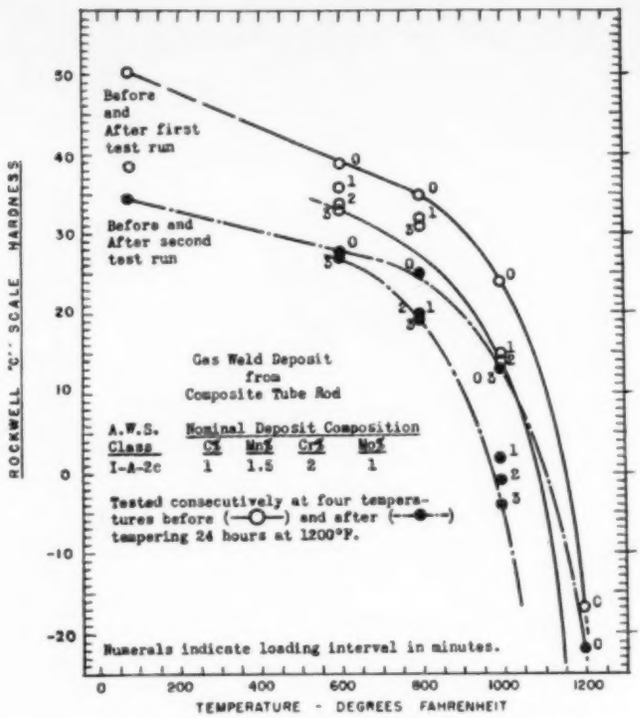


Figure 13 — Hot hardness of a gas weld deposit from a composite tube rod of the "air-hardening" or "self-hardening" type. The upper curves are as welded, while the lower curves show the different properties after tempering 24 hours at 1200 F.

tively high. This advantage is more marked when the effect of creep is considered; the cobalt-base alloys lose only a few points of hardness in 3 or 4 minutes at 1200 F, while the other types that exhibit C30 or above at this temperature lose many scale points in the first three minutes. Figures 10 and 11 are temperature-hardness plots of gas and arc welds. Up to 1000 F the effect of creep during a 3-minute interval is within the scatter band of experimental error, as is the difference in room temperature hardness before and after testing up through 1200 F. Thus creep and tempering effects can be considered negligible up to these values.

At 1200 F, three patterns were noticed in testing about a dozen gas and arc welds. Some deposits, like the 1.0 per cent C arc weld in Figure 11 held the 1000 F type of creep resistance up to 1200 F. Others gave a relatively sharp drop between 1000 and 1200 F like the 2.5 per cent C arc weld of Figure 11. The third pattern is intermediate between these two, like the two gas welds of Figure 10. These variations are attributed to differences in composition and structure as a result of segregation or dilution. They can occur for both carbon levels and both welding methods, but because of the likelihood of greater penetration and greater overlay dilution from base metal fusion, they are more to be expected with arc welds. The undesirable pattern, with a marked drop in creep resistance at 1200 F, should be consciously minimized during welding by avoiding such dilution.

The ranges and averages of tests on several specimens of each of two compositions appear in Table V. These are the most important of the hard-facing alloys with high hot hardness and they have been the most generally available.

Hot hardness alone does not sufficiently differentiate the 1.0 and 2.5 per cent carbon types, since other qualities, notably toughness, control their selection. The 1 per cent carbon alloy can be lathe turned with difficulty and subjected to some other machining operations, but the 2.5 per cent carbon grade must be shaped by grinding.* It contains very hard carbide spines of the Cr_7C_3 type, which will quickly dull even tungsten-carbide cutting tools.

Abrasion resistance differs considerably. The 2.5 per cent carbon grade has relatively good resistance to wear from abrasive particles like sand, though a number of other alloys will outperform it in such service. In contrast, the 1.0 per cent carbon material is poor for most abrasive conditions. It is quite unsuited for high stress grinding abrasion such as occurs in ball mills. As a principle, selection of these cobalt-base alloys should be based primarily on their properties above 1000 F.

A typically appropriate application is the surfacing of internal combustion engine valves, where resistance to hot gas corrosion and hot deformation is required along with some toughness to withstand the successive impacts of valve action. The 1.0 per cent carbon alloy is widely and successfully used for such work. At room temperature it has a tensile strength of about 100,000 psi with 1 per cent elongation (as determined on castings) and as temperature rises there is some tendency for ductility to increase.

As carbon increases, room temperature behavior becomes similar to that of cast irons and tensile tests are

* While the 2.5 per cent C alloy has been machined at 0.006-0.010 in. feeds with cemented carbide tools, it is unlikely that this would be more economical than grinding.

TABLE VI

PROPERTIES OF COBALT BASE ALLOYS

	AWS Class II-A			AWS Class II-B		
	Gas welded	Small castings*	Arc welded	Gas welded	Small castings*	Arc welded
Type composition, per cent	1 C, 28 Cr, 5 W, 55 Co			2.5 C, 31 Cr, 13 W, 43 Co		
Resistance to flow under repeated impact	Fair			Good		
Tensile toughness	Moderate			Low		
Oxidation resistance	Excellent			Excellent		
Maximum temperature considered advisable	2100 F			2100 F		
Creep resistance	Outstanding			Excellent		
Rockwell hardness						
at 70 F	C37-47	C40	C35-45	C45-60	C55	C45-60
600 F	C37	.....	C37	C50	.....	C53
800 F	C31-35	.....	C35	C47-48	.....	C50
1000 F	C27-31	C28	C31	C44-46	C45	C35-47
1200 F	C21-27	C22	C27	C40-44	C41	C35-36
Compression strength:						
0.10 per cent set yield — psi		64-81000			90-108000	
Ultimate — psi		155-209000			255-268000	
Elastic deformation — per cent		0.4-1.0			0.6-0.9	
Plastic deformation — per cent		4.3-9.0			1.9-2.2	
Abrasion resistance	Poor	Poor	Poor	Fair	Good	Poor
Wet sand abrasion factor	1.05-1.30	.....	1.15-1.35	0.63-0.85	.....	0.85-1.20
Erosion resistance	Fair	.....	.....	Excellent	.....	.....
Dry sand erosion factor	0.17	.....	.....	0.05	.....	.....
Tensile strength — psi		105000			.....	
Elongation, per cent		1.0			.....	
Brinell hardness		340			.....	

*Properties considered between those of gas and electric weld deposits. Used for some test specimens to eliminate welding variables and defects.

poorly adapted for comparisons. Since most service conditions involve compressive loading, compression tests are much more appropriate. Relative elasticity, strength and plasticity are compared against carbon

Figure 14 — Hot hardness of a gas welded chromium-molybdenum steel before and after tempering 24 hours at 1200 F. Numerals indicate loading interval in minutes.

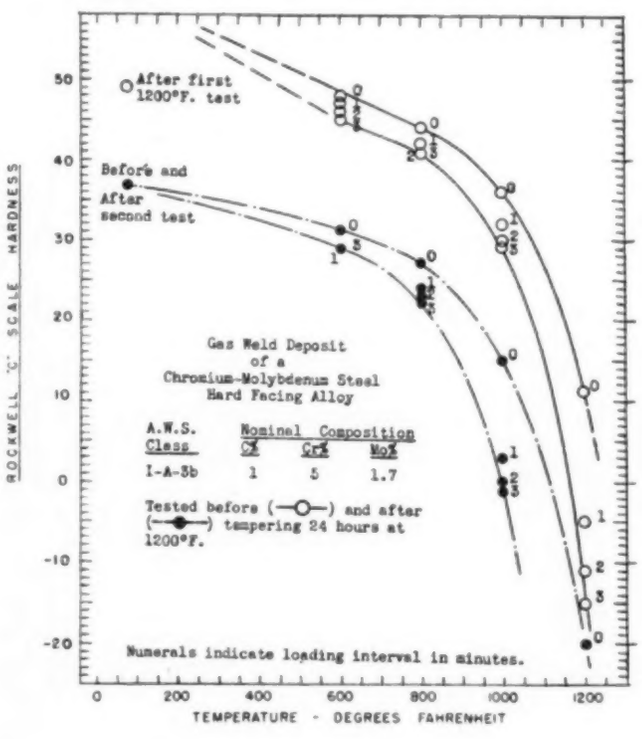

After first 1200°F. test
Before and After second test
Gas Weld Deposit of a Chromium-Molybdenum Steel Hard Facing Alloy
A.W.S. Class I-A-3b
Nominal Composition C% 1 Cr% 5 Mo% 1.7
Tested before (—O—) and after (—●—) tempering 24 hours at 1200°F.
Numerals indicate loading interval in minutes.
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

Figure 15 — Hot hardness of a high speed steel gas weld deposit before and after tempering 24 hours at 1200 F. Numerals indicate the time interval in minutes after load application.

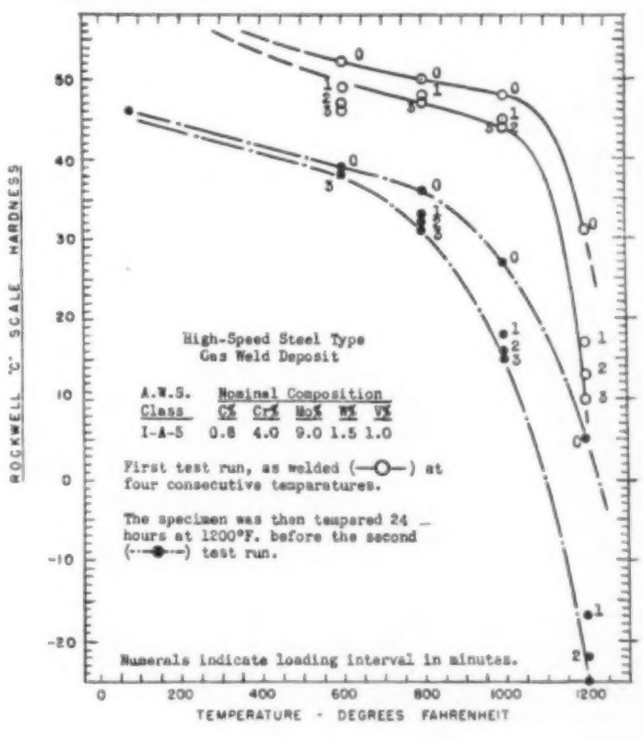

High-Speed Steel Type Gas Weld Deposit
A.W.S. Class I-A-5
Nominal Composition C% 0.8 Cr% 4.0 Mo% 9.0 W% 1.5 V% 1.0
First test run, as welded (—O—) at four consecutive temperatures.
The specimen was then tempered 24 hours at 1200°F. before the second (—●—) test run.
Numerals indicate loading interval in minutes.
ROCKWELL 'C' SCALE HARDNESS
TEMPERATURE - DEGREES FAHRENHEIT

TABLE VII

HARD FACING ALLOYS FOR STEEL MILL USE
APPROXIMATE CORROSION RESISTANCE OF SEVERAL ALLOYS
THAT CAN BE USED AS WELDED OVERLAYS

Corrosive media	Concentrations	Temp, F	Alloy type*				
			19-9	Cr-Ni-Mo	Cr steel	Ni-Mo Fe	Ni-Cr-Mo-W
Acetic acid	All %	70	G	G	...	G	G
	All %	Boil	G	G	X*	G	G
	All %	Any	G	G	...	G	G
Acetic anhydride	.....	70	G	G	G	G	G
		Boil	G	G	X	G	G
Acetone	.....	Boil	G	G	...	G	G
Alcohol (methanol)	.....	150	F	G	...	...	...
Alum	10%	Boil	G	G	X	...	...
Aluminum chloride	All %	Room	X	G	X	G	G
	All %	Any	X	...	X	G	X
Aluminum sulfate	.....	Boil	G	G	X	F	G
Amines	.....	.....	G	G	G	G	G
Ammonia	Wet	70-212	G	G	...	G	G
Ammonium chloride	All %	Any	X	X	X	G	F
	All %	Room	G	G	X	G	G
Ammonium carbonate	1 and 5%	Room	G	G	G	...	...
Ammonium hydroxide	All %	Room	G	G	...	G	G
Ammonium nitrate	All %	Boil	G	G	G	...	...
Ammonium phosphate	5%	Room	G	G	G	...	...
Ammonium sulfate	All %	Boil	F	G	X	F	G
	All %	Room	G	G	X	G	G
Amyl acetate	.....	.....	G	G	...	...	...
Amyl chloride	.....	.....	G	G	...	...	...
Aniline	.....	.....	G	G	...	...	...
Arsenic acid	.....	225, 150	G	G	...	...	...
Barium carbonate	.....	.....	G	G	...	...	...
Barium hydrate	.....	.....	G	G	...	...	...
Barium sulfide	.....	.....	G	G	...	...	...
Beer	.....	.....	G	G	...	...	...
Benzoic acid	.....	.....	G	G	...	...	...
Benzol	.....	.....	G	G	...	...	...
Borax	.....	.....	G	G	...	...	...
Borix acid	.....	.....	F	G	...	...	...
Brine	.....	.....	F	G	...	...	...
Bromine	Dry	.....	X	G	X	G	G
	Wet	.....	X	X	X	X	F
Butyl acetate	.....	.....	G	...	...	...	...
Butyric acid	5%	150	G	G	G	...	...
Calcium bisulfite	.....	Hot	F	G	...	...	...
Calcium carbonate	.....	.....	G	G	...	...	...
Calcium chloride	.....	Room	F	G	X	G	G
		Hot	X	G	X	G	G
Calcium hypochlorite	2%	Room	G	G	X	X	G
	Conc.	.....	X	F	X	X	X
Calcium hydroxide	.....	.....	G	G	...	...	...
Carbon bisulfide	.....	.....	G	G	...	...	...
Carbon dioxide	.....	.....	G	G	...	...	...
Carbon tetrachloride	CP	70 & Boil	G	G	G	G	G
	Comm.	70	G	G	G	G	G
Carbonic acid	.....	.....	G	G	G	G	G
Chloracetic acid	.....	.....	X	X	X	G	G
Chloric acid	.....	70	X	X	...	...	...
Chlorinated H_2O	Sat.	70	X	F	...	...	...
Chlorine	Dry	.....	X	G	X	...	...
	Wet	.....	X	X	X	X	X
Chlorosulfonic acid	.....	.....	G	...	...	...	...
Chromic acid	50%	70	G	G	...	X	G
	50%	Boil	X	G	X	X	G
Citric acid	50%	70	G	G	F	G	G
	50%	Boil	X	G	...	G	G
Coffee	.....	.....	G	G	...	...	...
Copper carbonate	.....	.....	G	G	...	...	...
Copper chloride	.....	.....	F	...	...	...	...
Copper nitrate	.....	.....	G	G	G	...	...
Copper sulfate	Cuprous	.....	G	G	G	G	G
	Cupric	.....	G	G	G	X	G
Ethers	.....	.....	G	G	...	...	...
Ethyl acetate	.....	.....	G	G	G	...	...
Ethyl alcohol	.....	.....	G	G	G	...	...
Ethyl glycol	.....	.....	G	G	G	...	...
Fatty acids	.....	.....	G	G	G	G	G
Ferric chloride	.....	.....	X	X	X	X	F
Ferric nitrate	.....	.....	G	G	...	...	...
Ferric sulfate	.....	.....	G	G	G	X	G
Ferrous sulfate	.....	.....	G	G	G	G	G
Fluorine	.....	70	X	X	...	...	...
Formaldehyde	All %	All	...	G	...	G	G
	40%	70	G	...	G	...	...
Formic acid	All %	All	X	G	X	G	G
	5%	150	G	G	X	G	G
Fruit Juices	.....	70	G	G	...	...	...
Furfural	.....	.....	G	G	...	...	...
Gasoline	.....	.....	G	G	...	...	...
Gelatin	.....	.....	G	G	...	...	...
Glue	.....	.....	G	G	...	...	...
Glycerine	.....	.....	G	G	...	...	...
Hydrocarbon (aliphatic)	.....	.....	G	G	G	G	G
Hydrocarbon (aromatic)	.....	.....	G	G	G	G	G
Hydrochloric acid	1%	70	G	G	X	G	G
	All %	160	X	X	X	G	X

Corrosive media	Concentrations	Temp, F	Alloy type*				
			19-9	Cr-Ni-Mo	Cr steel	Ni-Mo-Fe	Ni-Cr-Mo-W
Hydrochloric acid	All %	70	X	X	X	G	G
Hydrofluoric acid	All %	Boil	X	X	X	X	G
	All %	70	X	X	X	G	G
	5%	70	G	F	X	G	G
Hydrogen peroxide	.....	.....	G	G	F	F	G
Iodine	Dry	70	G	G	X	X	X
	Wet	70	X	X	X	X	G
Lactic acid	All %	All	X	G	X	G	G
	5%	70	G	G	X	G	G
Lead acetate	.....	.....	G	G	...	...	...
Lead nitrate	.....	.....	G	G	...	...	...
Lysol	.....	.....	G	...	...	...	...
Magnesium carbonate	.....	.....	G	...	...	...	...
Magnesium chloride	Conc.	.....	X	G	X	G	G
	5%	70	G	G	X	G	G
Magnesium hydroxide	.....	.....	G	G	...	...	...
Magnesium sulfate	.....	.....	G	G	...	...	...
Malic acid	.....	.....	G	G	F	...	...
Mercuric chloride	.....	.....	X	F	...	...	...
Mercurous sulfate	.....	.....	F	G	...	...	...
Mercurous nitrate	.....	.....	G	G	...	...	...
Milk	.....	.....	G	G	F	...	...
Mixed acid	50-50 & 75-25	200 & 140	G	G	...	X	G
	50-50 & 75-25	Boil	F	G	...	X	X
	70-10	Boil	X	G	...	X	X
Mine waters	.....	.....	G	G	...	...	...
Naphtha	.....	.....	G	G	...	...	...
Nitric acid	All %	All	...	G	...	X	...
	All %	70	G	G	F	X	G
	Conc.	Boil	X	G	X	X	X
	Up to 65%	Boil	G	G	X	X	X
Oleic acid	.....	.....	G	G	G	G	G
Oleum	.....	.....	F	G	...	...	...
Oxalic acid	All %	All	...	G	...	G	G
	10%	70	G	G	...	G	G
	10%	Boil	X	G	...	G	G
Phenol	All %	All	F	G	F	G	G
Phosphoric acid	All %	160	X	G	...	G	G
	10%	70	X	G	...	G	G
	10%	Boil	X	G	...	G	G
	5%	70	G	G	...	G	G
Picric acid	.....	.....	G	G	...	...	...
Potassium chloride	.....	.....	G	G	...	...	...
Potassium hydroxide	.....	.....	G	G	...	...	...
Potassium nitrate	1-5%	70	...	...	...	...	...
		Boil	G	G	G	...	...
Sea water	.....	.....	F	G	F	G	G
Sodium bicarbonate	.....	.....	G	G	G	...	...
Sodium bisulfate	10%	.....	G	G	G	G	G
	Conc.		X	G	...	G	G
Sodium carbonate	Molten	1650	X	G	...	...	...
	5 & 50%	Boil	G	G	G	G	G
Sodium chloride	.....	.....	F	G	F	G	G
Sodium hydroxide	Strong	.....	X	G	X	G	G
	Weak or Med.	.....	G	G	G	G	G
Sodium hypochlorite	.....	.....	X	F	X	X	F
Sodium nitrate	.....	.....	G	G	G	X	G
Sodium peroxide	.....	.....	G	G	...	...	...
Sodium phosphate	.....	.....	G	G	...	...	...
Sodium sulfate	.....	.....	G	G	G	G	G
Sodium sulfide	.....	.....	F	G	G	G	G
Sodium sulfite	.....	.....	F	G	X	X	G
Sodium thiosulfate	.....	.....	G	G	G	G	G
Steam	.....	.....	G	G	G	...	...
Stearic acid	.....	.....	G	G	G	G	G
Sulfite liquors	.....	.....	F	G	...	...	...
Sulfur	Dry	.....	G	G	...	X	X
	Wet	.....	X	G	...	X	X
Sulfur dioxide	Dry	575	G	G	G	...	...
	Wet	.....	F	G	X	F	G
Sulfuric acid	10%	70	X	G	X	G	G
NOTE: 55-70% cocentration is critical and should be considered as a special case.	10%	Boi	10%		Boil	X	G
	50%	70	F	G	...	G	G
	50%	Boil	X	X	X	G	G
	Conc.	70	G	G	G	G	G
	Conc.	300	X	X	...	...	G
Sulfurous acid	Sat.	70	G	G	X	G	G
	150 psi	350	F	G	X	G	G
Tannic acid	10%	70	G	G	...	...	...
	10%	Boil	X	G	...	...	...
	50%	Boil	...	...	...	...	...
		70	G	G	...	...	...
Tar	.....	.....	G	G	...	...	...
Tartaric acid	.....	70	G	G	F	...	...
		150	G	G	X	...	...
Trichloroethylene	.....	Boil	G	G	X	G	G
Vegetable juices	.....	.....	G	G	...	...	...
Vinegar	.....	.....	G	G	...	...	...
Zinc chloride	.....	.....	X	G	...	...	...

Type*	Nominal composition, per cent					
	C	Cr	Ni	Mo	W	Fe
19-9	0.07-0.20	19	9	....	....	....
Cr-Ni-Mo	0.10 max	22	28	2	....	....
Cr steel	0.10-0.30	12-20	....	....	....	....
Ni-Mo-Fe	0.15 max	....	Bal	21	....	21
Ni-Mo-Cr-W	0.15 max	....	Bal	16	4	6

G = Good, less than 0.005 in. per year.
F = Fair, between 0.005 and 0.05 in. per year.
X = Not recommended, more than 0.05 in. per year.

TABLE VIII

PROPERTIES OF NICKEL BASE ALLOYS

	AWS Class V-B			AWS Class V-C		
	Gas welded	Small castings*	Arc welded	Gas welded	Small castings*	Arc welded
Type composition, per cent	3.75 B, 17 Cr, 70 Ni			0.10 C, 13 Cr, 18 Mo, 5 W, 50-65Ni		
Resistance to flow under repeated impact		.....			.....	
Tensile toughness		Low			High	
Resistance to cracking under repeated impact		Low			High	
Oxidation resistance		Good			Good	
Maximum temperature considered advisable		1500 F			1500 F**	
Creep resistance		Good			Good	
Rockwell hardness						
at 70 F	C56-62	.....	C42-50	C24-32	C13-C24	.....
600 F	C55	.....	C49	.....	.....	.....
800 F	C52	.....	C46	.....	.....	.....
1000 F	C48	.....	C39	C16	C-1-C8	.....
1200 F	.....	.....	.....	C7	C0-C3	.....
Abrasion resistance	Poor	.....	Poor	Poor	.....	.....
Wet sand abrasion factor	0.90	.....	1.12	0.97	.....	.....
Erosion resistance	Good	.....	.....	Poor	.....	.....
Dry sand erosion factor	0.076-0.082	.....	.....	0.73	.....	.....
Tensile strength — psi	.....	.....	.....	.....	71500	.....
Elongation — per cent	.....	.....	.....	.....	15.0	.....
Brinell hardness	.....	.....	.....	.....	190	.....

*Properties considered between those of gas and electric weld deposits. Used for some test specimens to eliminate welding variables and defects.
**Molybdenum bearing alloys are subject to catastrophic oxidation under some conditions.

(and tungsten) by this criterion in Table VI. Note that the softer and weaker of the two types will deform more readily in compression, but that once plastic behavior begins, with 1.0 per cent C there is a greater reserve of plasticity before failure occurs. These data are useful in judging relative performance in applications where experience has not yet clarified the selection problem. The indicated plasticity is valuable for redistribution of concentrated stresses that might otherwise become dangerous, particularly where some impact is involved.

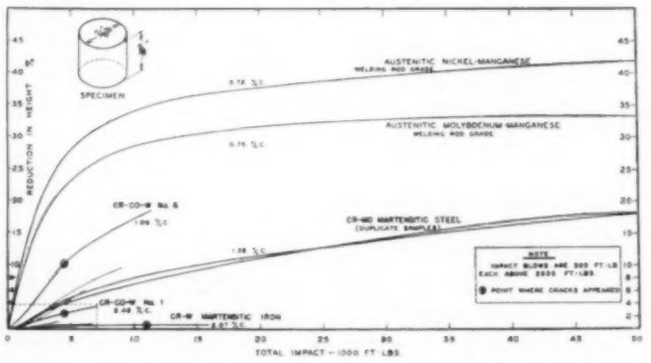
NICKEL BASE ALLOYS

The primary contribution of nickel in hard facing alloys is corrosion resistance. It can also add creep strength in some cases, and thereby confer resistance to hot wear. However, the high nickel alloys are usually not particularly abrasion resistant. Erosion resistance can be satisfactory. Each of the properties except corrosion resistance can ordinarily be obtained in some other alloy at less cost.

Corrosion is so complex that simple generalizations that might aid in selection are seldom satisfactory. However, the data in Table VII may be helpful. The nickel base alloys are not interchangeable, and therefore they should be selected and applied with caution. They are related to and may merge into compositions that are stainless steels. These may also carry various percentages of carbon and thus range in mechanical properties from levels approximating steels to those resembling cast iron. Nickel will suppress the martinsitic reaction, however, and the nickel base alloys do not harden by this mechanism. Hardening usually is obtained by additions or combinations of chromium, molybdenum, boron, and the like, which are especially effective when associated with carbon. (Table VIII).

The chromium-nickel stainless steels are less costly, and, therefore, should be considered before a nickel base alloy is selected. Chromium is more potent in conferring oxidation resistance.

Figure 16 — Effects of repeated impact on hard facing alloys.



MARTENSITIC STEELS

The hardness and high strength of tool steels are utilized daily by engineers. In most cases these properties are developed by heat treatment that involves liquid quenching from a red heat, which forms the structure known as martensite, and a subsequent tempering at a lower temperature. Much of the performance of such hardened steels can be attained in weld deposits. However, the composition must be adjusted to allow the alloy to harden as the weld cools. Welding alloys so formulated are available in variety, the choice between them being sometimes difficult. As a simpli-

TABLE IX

PROPERTIES OF HADFIELD'S AUSTENITIC MANGANESE STEEL

Type	Form	Composition, per cent				Yield strength, psi	Tensile strength, psi	Elongation, per cent	Reduction in area, per cent	Hardness, BHN	V—notch impact Izod Charpy
		C	Mn	Si	Ni						
Std*	Cast 1-in. round	1.0	10	0.2	*	50000	100000	30	30	185	100 = 90
		1.4	14	1.0		57000	145000	65	40	210	220
Std *	Rolled 1-in. round	1.1	11	0.2	*	50000	131000	40	35	170	90
		1.4	14	0.6		60000	142000	60	50	200	150
Ni-Mn*	Cast 1-in. round	0.84	12.5	0.48	3.46*	.....	105000	45	35	170	95
							127000	65	45	180	106
Ni-Mn*	Cast 1-in. round	1.10	12.5	...	3.1*	.....	113000	44	35	150	105±
		1.17	12.7		3.6		140000	70	45	170	
Ni-Mn	Rolled	1.1	10	0.2	3.25	50000	130000	48	40	165	90
		1.4	14	0.6	3.75	63000	155000	72	60	195	150

*Toughened by water quenching.
Work hardening capacity: From 170-200 BHN to 450-550 BHN
Specific gravity: 7.9. Density 0.286 lb/cu in. = 493 lb/cu ft
Melting point: 2450 F
Thermal conductivity: 2.31 vs copper at 100**
Electrical resistivity: 70 microhms/cm cube or about 7 times that of pure iron***
Electrical conductivity: 0.0143 megmhos per cm cube***
Specific heat (thermal capacity): 0.12 g cal/g/°C
Thermal conductivity (0.8%c, 3%Ni)* 0.031 cal/cm/cm/sec/°C = 90 Btu/sq ft/in./°F***
Magnetic permeability: 1.003-1.03 (H = 24)
Magnetic permeability without surface preparation: 1.30±
Wet quartz sand abrasion factor: 0.75-0.85 (vs SAE 1020 as 1.00) (4)
Elastic modulus: 24-30,000,000 psi

Thermal expansion coefficients:
in. per in. per °F, average

100-300 F	0.0000102
100-500 F	0.0000113
100-700 F	0.0000119

Instantaneous

100 F	0.0000102
200 F	0.0000106
300 F	0.0000111
400 F	0.0000119
500 F	0.0000126
600 F	0.0000134
700 F	0.0000136

Footnotes:
*Swanger, "ASTM-ASME Symposium on Effect of Temp. on Metals," 1931, p. 732
**Pennington, H. R., "Engineering and Contracting," February, 1922
***Varies with heat treatment

fication, it is usually satisfactory to use a steel known to harden by the martensitic reaction for general wear resistance and a high speed steel type if high hot hardness is desired as well. The relative abrasion resistance of two types appears in Figure 12; hot hardness in Figures 13, 14 and 15 and an indication of impact resistance in Figure 16.

These steels are to be preferred where a combination of toughness and abrasion resistance is needed. They occupy a position between the martensitic irons and the austenitic steels in this respect; indeed this trio will serve most hard facing needs unless hot hardness above 1100 F is an important factor.

PEARLITIC STEELS

Not all steels that air harden somewhat are martensitic. By ignorance in formulation or by design, many of them form pearlite as the weld cools. Such steels are inexpensive, or should be, and are to be preferred only where the lower cost does not sacrifice performance. They have a legitimate field in building up worn areas that are later topped with a more competent alloy. They serve well where conditions are not severe enough to make a 2:1 difference against a better alloy apparent, and where, therefore, the facing must be replaced at each overhaul period.

A simple steel with about 0.90 per cent carbon can represent this group. The presence of alloys is usually undesirable if the deposits are to be built up to a considerable thickness. Cracking is likely to be promoted by the greater hardenability conferred by alloys.

AUSTENITIC STEELS

Alloys beyond the amounts required to make air hardening martensitic weld deposits will tend to sta-

TABLE X

THE CONTRIBUTION OF ALLOY ELEMENTS

TO AUSTENITIC MANGANESE STEEL PROPERTIES

Heat No.	Composition, per cent					
	C	Mn	Si	Ni	Mo	
Average expectancy	1.12	12.5	0.5	....	....	Standard Mn steel, cast
49-240	0.61	11.9	0.34	0.16	....	Low-carbon Mn steel
49-304	0.73	11.5	0.37	0.20	....	Low carbon Mn steel
49-210	0.61	11.8	0.17	....	1.05	Molybdenum-Mn steel
50-546	0.75	13.9	0.58	....	0.94	Molybdenum-Mn steel
50-280d	0.72	12.6	0.54	3.41	....	Nickel-Mn steel

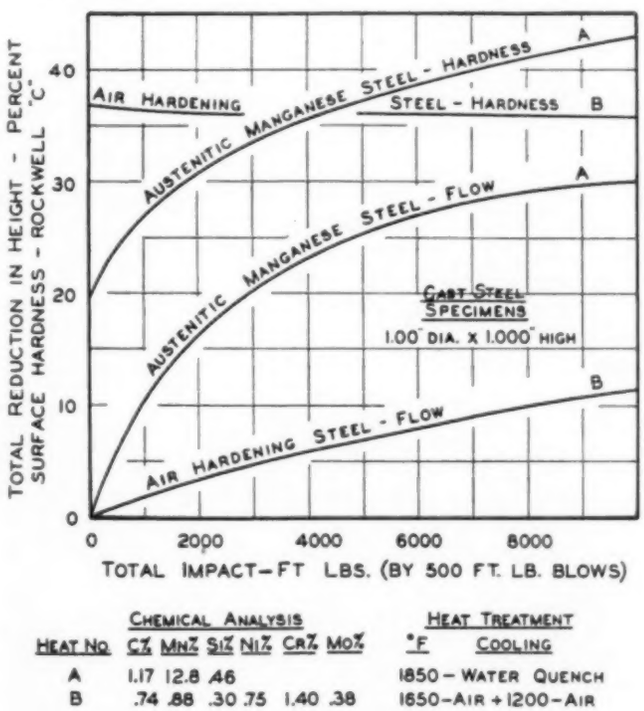
Material	Yield strength, psi	Ultimate tensile strength, psi	Elongation in 2 in., per cent	Reduction in area, per cent	Hardness, BHN	Heat treatment, °F hrs Q.
Std. Mn steel	53,000	124,000	45	35	195	Water quenched
0.61%C Mn steel	42,000	96,750	21	18	167	1900-2-Water
0.73%C Mn Steel	46,000	109,250	33	28	163	1900-2-Water
0.61%C Mo-Mn	47,000	110,500	35	26	175	1900-2-Water
0.75%C Mo-Mn	52,500	131,500	59	38	207	1900-2-Water
0.72%C Ni-Mn	44,500	121,500	58	36	187	1900-2-Water

bilize austenite, the high temperature form of steel. When correctly formulated, steels can consist entirely of austenite at room temperature. Thirteen per cent manganese (Table IX) and 18 Cr: 8 Ni are two such types. They have many relatives, particularly in the Cr-Ni-iron group.

The austenitic steels have several unique properties. They are expected to be non-magnetic and thus can be tentatively separated out of mixtures by means of a small magnet. They have relatively low yield strength values and, therefore, deform easily. They are initially soft, but if deformed by cold work they harden markedly. They are usually very ductile as well as high in ultimate strength. This combination makes them the preferred types where impact is heavy, deformation cannot be avoided, and tension stresses are likely.

Manganese steel[2] is the least expensive of this group and has the distinction of work hardening more (and absorbing more energy in the process) than any other commonly available engineering material (Figure 17). It is the logical choice where heavy impact is involved in association with other wear factors. It has

Figure 17 — Plastic flow and work hardening characteristics of austenitic manganese steel under repeated impact.


TOTAL REDUCTION IN HEIGHT - PERCENT
SURFACE HARDNESS - ROCKWELL "C"
AUSTENITIC MANGANESE STEEL - HARDNESS
AIR HARDENING STEEL - HARDNESS
AUSTENITIC MANGANESE STEEL - FLOW
AIR HARDENING STEEL - FLOW
CAST STEEL SPECIMENS
1.00" DIA. X 1.000" HIGH
TOTAL IMPACT - FT LBS. (BY 500 FT. LB. BLOWS)

Heat No	Chemical Analysis C%	Mn%	Si%	Ni%	Cr%	Mo%	Heat Treatment °F	Cooling
A	1.17	12.8	.46				1850	Water Quench
B	.74	.88	.30	.75	1.40	.38	1650	Air + 1200 - Air

Figure 18 — Embrittlement from reheating austenitic manganese steel.

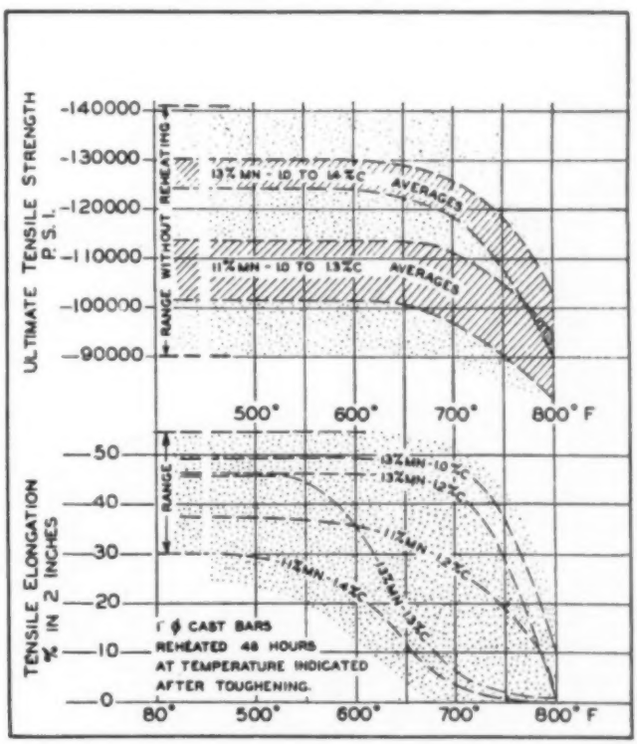

ULTIMATE TENSILE STRENGTH P.S.I.
RANGE WITHOUT REHEATING
13% MN - 1.0 TO 1.4% C AVERAGES
11% MN - 1.0 TO 1.3% C AVERAGES
TENSILE ELONGATION % IN 2 INCHES
RANGE
1" ϕ CAST BARS REHEATED 48 HOURS AT TEMPERATURE INDICATED AFTER TOUGHENING.

TABLE XI

MECHANICAL TEST PROPERTIES OF AUSTENITIC NICKEL-MANGANESE STEEL

Chemical Analysis — Per cent

C	Mn	Si	Ni
0.84	12.45	0.48	3.46

Tensile Properties After Toughening By Water Quenching From Above 1800 F

Grain size	Yield strength, psi	Ultimate tensile strength, psi	Elongation in 2 in., per cent	Reduction in area, per cent	Hardness, BHN
Coarse	44,500	106,250	49.5	41.2	174
Fine	45,700	121,750	60.0	41.5	174

Tensile Properties After Reheating the Toughened Steel

Reheating		Grain size	Ultimate tensile strength, psi	Elongation in 2 in., per cent	Reduction in area, per cent	Hardness, BHN
Temp F	Time, hrs					
500	48	Coarse	106,250	49.0	39.4	177
600	48	Coarse	106,500	50.0	42.7	174
700	48	Coarse	105,750	53.0	37.8	165
800	48	Coarse	105,250	47.5	41.5	174
500	48	Fine	123,750	62.5	40.3	174
600	48	Fine	125,000	63.5	39.7	174
700	48	Fine	125,500	61.0	40.0	172
800	48	Fine	127,000	65.0	42.1	179

Notched Bar Impact Toughness
Machine Ground "V" Notch Charpy Specimens
Energy Absorbed in Foot Lbs

At room temperature	At 100 F below zero
94-106	75-84

fair abrasion resistance, but should not be selected primarily for this. Martensite steels and irons are more economical where little or no tensile impact is involved.

Manganese steel is not corrosion resistant, is embrittled by temperatures above about 500 F (Figure 18), and is very difficult to machine. These factors should be considered in selection.

Austenitic manganese steel castings are common in many steel mills. Car and crane wheels, sprockets, chains, wearing plates and liners, crusher parts, nonmagnetic parts and the like are well known applications. Where the surface qualities for resisting metal to metal wear associated with impact are needed, either as a build up for worn parts or as an initial protection, electrodes can be obtained that have similar properties.

The welding alloys are modified because, unlike the castings, weld deposits are not heat treated by quenching before use. The brittle structures that occur in castings upon slow cooling are avoided by a lower carbon range (around 0.80 per cent C vs 1.20 per cent for castings). At the same time the effect of this lowered carbon on mechanical properties is compensated by additions of nickel, molybdenum, or other alloying elements. Examples appear in Tables X and XI.

Several precautions are necessary in welding with manganese steel.[3] If the base is also austenitic manganese steel it should be heated as little as possible and weld bead dilution held to a minimum. If the base is not austenitic, a pad of austenitic stainless steel, like 25 Cr: 20 Ni, should be interposed. If carbon or low alloy steels are mixed with 13 per cent manganese in the weld bead, an inferior, brittle alloy results.

Like most austenitic alloys, weld cracks or fissures are likely to follow excessive thermal stresses, particularly if much base metal is mixed in the bead. Such cracks are minimized by using low arc power and relatively large beads. Data from a factorial experiment to demonstrate this are summarized in Figure 19, which shows graphically the relation between arc power and bead cracking tendencies. Peening of the red hot weld bead also will minimize cracks.

The stainless austenitic steels are usually more stable than 13 per cent Mn steel and where this factor, which permits heating in service, or their corrosion resistance and hot strength are required, they are logical substitutes. Their advantages must be balanced against greater cost. Superficially they are less susceptible to cracking, but this effect stems largely from the coating employed. Manganese steel welding is usually done with bare electrodes because of the high burn-off rate that is possible. (Coatings usually reduce arc power and burn-off rate because they lower arc voltage).

Beyond the data included for comparisons in Table VII, under nickel-base alloys, the resistance of stainless steels to liquid corrosion is too complex for treatment here. However, where oxidation or hot gas cor-

TABLE XII

PROPERTIES OF IMPORTANT HEAT RESISTANT ALLOYS*

Type	28Cr	21Cr : 9Ni	26Cr : 12Ni	26Cr : 20Ni	16Cr : 35Ni	12Cr : 60Ni
A.C.I. designation	HC	HF	HH	HK	HT	HW
C% (1)	0.30	0.25-0.35	0.30-0.40	0.27-0.71	0.35-0.70	0.31-0.77
Ni%	0-3	8-11	10-13	19-21	34-37	59-62
Cr%	27-30	18-23	23-27	23-26	13-17	10-14
ROOM TEMPERATURE TENSILE PROPERTIES (2) ON SMALL CASTINGS						
Yield strength—psi	.....	40-50,000	40-54,000	62-83,000	40-53,000	36-39,000
Ultimate strength—psi	67,250	73-95,000	80-95,000	66-100,000	65-71,000	68-78,000
Elongation—per cent	0.5	27-47	14-40	6-26	5-14	3-13
Reduction in area—per cent	0.5	26-40	13-45	7-25	5-18	4-11
Hardness—BHN	238	163-181	160-190	175-202	150-195	160-220
HOT GAS CORROSION AS METAL LOSS IN INCHES PER YEAR (3)						
In air at 1600 F	0.019	0.013	0.007	.....	0.0063	0.0055
	0.017	0.001	0.005	0.004	0.004	0.0043
In air at 1800 F	0.048	0.14	0.039	0.025	0.029	0.012
	0.038	0.037	0.030	0.02	0.0097	0.0092
In air at 2000 F	0.063	0.6	0.097	0.07	0.26	0.045
	0.05	0.1	0.071	0.049	0.048	0.037
In oxidizing flue gas						
5gS per 100 cu ft—1800 F	0.029	0.14	0.036	0.029	0.075	0.038
	.....	0.035	0.029	0.026	0.025	0.024
100 gS per 100 cu ft—1800 F	0.033	0.12	0.033	0.027	0.085	0.05
	0.03	0.033	0.027	0.024	0.024	0.028
5 gS per 100 cu ft—2000 F	0.50	1.0	0.5	0.15	0.30	0.07
	0.15	1.0	0.10	0.05	0.07	0.025
100 gS per 100 cu ft—2000 F	0.17	1.0	0.12	0.07	0.25	0.07
	0.07	0.10	0.07	0.03	0.04	0.02
In reducing flue gas						
5 gS per 100 cu ft—1800 F	0.026	0.34	0.048	0.028	0.056	0.027
	0.025	0.046	0.026	0.022	0.026	0.017
100 gS per 100 cu ft—1800 F	0.034	0.48	0.036	0.025	0.46	1.8
	.....	0.034	0.028	0.022	0.036	0.036
5 gS per 100 cu ft—2000 F	0.25	1.0	0.3	0.10	0.15	0.03
	0.04	0.3	0.035	0.02	0.04	0.02
100 gS per 100 cu ft—2000 F	0.5	1.0	0.5	0.10	1.0	1.0
	0.07	0.4	0.05	0.025	0.10	0.025

*In the design of H.R.A. parts, creep and rupture strength are vital properties; in weld overlays they may usually be neglected as the load carrying properties of the base metal overshadow them.

(1) Nominal range to cover tensile properties given here; not part of usual specifications.

(2) Data from research program of The Electro Alloys Division, Elyria, Ohio.

(3) Data from research program sponsored by the Alloy Casting Institute at Battelle Institute; test specimens provided by the experimental foundry of the American Brake Shoe Co. The significant elements other than Cr and Ni were: C: 0.31-0.50%; Mn: 0.67-0.90%; Si: 0.76-1.35%; and N: 0.01-0.14%. The ranges given reflect the Cr and Ni extremes.

rosion resistance is required in an overlay, the data in Table XII are helpful.(4)

COPPER BASE ALLOYS

The classification in Table II omits copper alloys. They usually can be eliminated if inventories must be held to a minimum. However, the aluminum bronze alloys have certain properties that merit attention. They perform well in metal to metal wear, probably because they develop a film of aluminum oxide that inhibits welding wear. While they are softer than the usual hard facing alloys, they work well as mating faces against hard steel or the martensitic irons. Sprockets, pinions, and the like are frequently surfaced with aluminum bronze.

Some corrosion conditions lead to selection of copper alloys, but this area is again outside the scope of this paper.

One survey of steel mill experience indicates use of the grades described in something like the following proportions:

	Per cent
Tungsten carbide composites	?
High chromium irons	3
Martensitic irons	17
Cobalt base alloys	12
Nickel base alloys	3
Martensitic steels	34
Pearlitic steels	15

Austenitic steels	Per cent
Manganese	7
Stainless	7
Aluminum bronze	2

This may not conform to the experience of any single steel plant, since it is a composite of several, but it may be useful for comparisons. It is worthy of emphasis that current practice is frequently the result of trial and error, and if the sampling of available materials was not comprehensive, the optimum material may not have been selected. Even comparative tests may be misleading because the reproducibility of service tests is frequently poor and experimental errors, which may be concealed, can seriously interfere with valid deductions. There is no easy answer to this problem because service conditions are unlikely to be constant, and therefore successful experience in one mill cannot always be translated to another.

It is surprising that the survey just mentioned did not indicate important use of the composite tungsten carbide type. This may reflect absence of severe abrasive wear in steel plants, with metal to metal and high temperature conditions paramount. However, it seems more likely that it is due to lack of experience or understanding of tungsten carbide hard facing. In contrast, the oil drilling industry uses impressive amounts.

Without pretense that a different viewpoint will solve all difficulties, the following discussion is offered to provide a way for steel mill engineers to analyze the wear factors that occur in service and to select hard facing alloys as protection with reasonable assurance. It is based on a group of laboratory tests that have good reproducibility and that provide many facts to aid the exercise of engineering judgment.

The salient wear factors to be considered are impact, heat, friction and abrasion. By omitting liquid corrosion and vibration the approach is simplified.

IMPORTANT TYPES OF WEAR

In a simple classification, wear can be attributed to three basic factors: thermal, chemical and mechanical. However, these not only combine and interact, but also each of them can operate with many variations.

Mechanical wear is the result of stress. Complexity arises from the many ways in which stress may be applied and distributed. If the stresses are applied through hard particles, usually of a foreign and nonmetallic material, the wear is typed as erosion or abrasion. If the stress arises from collapsing bubbles in a turbulent fluid it may produce cavitation erosion. If from the interference of metal surfaces in motion, it can be called frictional. Stress, by forcing clean surfaces into intimate contact, may also cause seizure, galling, scuffing, scoring and the like. These phenomena may be typed as welding wear, and are usually associated with friction under conditions of poor or incomplete lubrication.

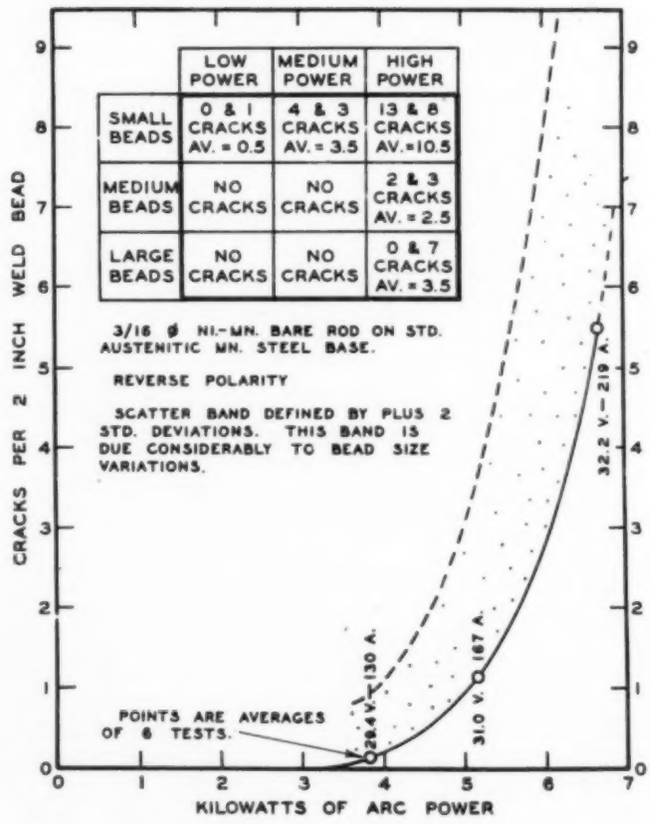
Impact — Impact is a stress producer. Both the kinetic energy and the velocity of an impact blow determine whether this energy can be absorbed and then returned by fully elastic behavior, or whether plastic deformation will result. In the first case no structural damage results, and engineers can select materials that will have the necessary elastic strength provided the velocity is not too high. The relatively light but incessant impact blows that characterize some machine parts such as tappets, cams, etc., are examples. Martensitic irons and steels with carefully adjusted compositions can provide outstanding protection for such parts. The property apparently responsible is high compressive strength.

Beyond a critical velocity [5] or under blows of great energy, it is not possible to avoid plastic deformation of the part struck. Battering then takes place and failure may be induced as cracks develop from excessive deformation. Ductility here becomes an asset, and if coupled with strength, provides the best defense. Austenitic manganese steel has an optimum combination of strength and ductility, coupled with a resistance to crack propogation that is outstanding. However, it has a low yield strength, and will batter down more rapidly than harder steels.

Some martensitic steels have valuable intermediate properties: higher yield strength than manganese steel though less toughness and ductility, more flow resistance though less resistance to damage from plastic deformation, and less abrasion resistance, but more toughness than the martensitic irons. They serve well in the intermediate field between light and heavy impact.

Design can aid considerably by providing proper support for impact blows and thus preventing structural damage from plastic deformation. Chilled cast

Figure 19 — Apparent dependance of weld bead cracking on arc power and bead size.



iron is usually rated as a very brittle material quite unsuitable for impact service. Despite this, the chilled iron freight car wheels on our railways take the impact blows of heavy cars at high speed as they go over bumpy crossings (the impact energy at the wheel-rail interface may be as much as 50,000 ft lb) without damage, because the contact points are well supported. The stresses are compressive, plastic flow is avoided, and no structural damage results.

Impact blows that produce high tensile stresses are almost certain to cause damaging deformation to martensitic structures, though they can be absorbed by manganese steel. Here again the designer can avert

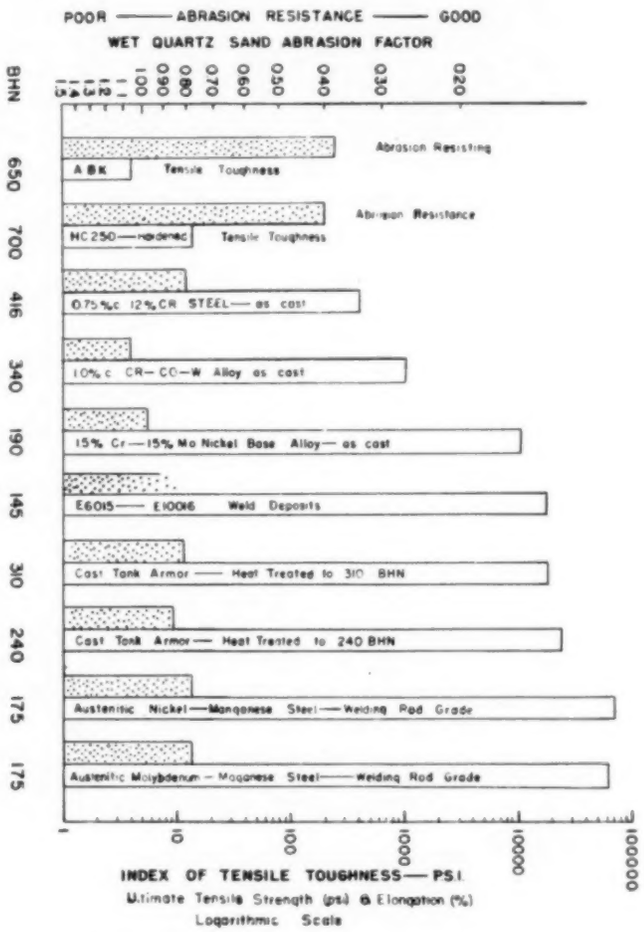

POOR —— ABRASION RESISTANCE —— GOOD
WET QUARTZ SAND ABRASION FACTOR
BHN
100 090 080 070 060 050 040 030 020
650
700
416
340
190
145
310
240
175
175
Abrasion Resisting
A 8K Tensile Toughness
Abrasion Resistance
NC 250 — hardened Tensile Toughness
0.75 %c 12% CR STEEL — as cast
10% c CR — CO — W Alloy as cast
15% Cr — 15% Mo Nickel Base Alloy — as cast
E6015 — E10016 Weld Deposits
Cast Tank Armor — Heat Treated to 310 BHN
Cast Tank Armor — Heat Treated to 240 BHN
Austenitic Nickel — Manganese Steel — Welding Rod Grade
Austenitic Molybdenum — Magnese Steel — Welding Rod Grade
1 10 100 1000 10000 100000
INDEX OF TENSILE TOUGHNESS — PSI
Ultimate Tensile Strength (psi) & Elongation (%)
Logarithmic Scale

Figure 20 — Relative abrasion resistance and tensile toughness of a graded series of wear resisting alloys.

failure by appropriate geometry of a part, causing impact blows to produce only compressive stresses.

It is not always obvious that impact stresses may be transmitted through a competent hard overlay and cause deformation of the underlying base. This can lead to high residual tensile stresses on the underside of the overlay, and subsequent impact will add to them. If base deformation is progressive, cracking of the overlay is almost certain to follow. The solution is selection of a stronger base metal or of a more ductile overlay material. The second choice usually leads to austenitic manganese steel, but provision of a competent base is sometimes more satisfactory if the impact blows are not too heavy. It should be noted that abrasion resist-

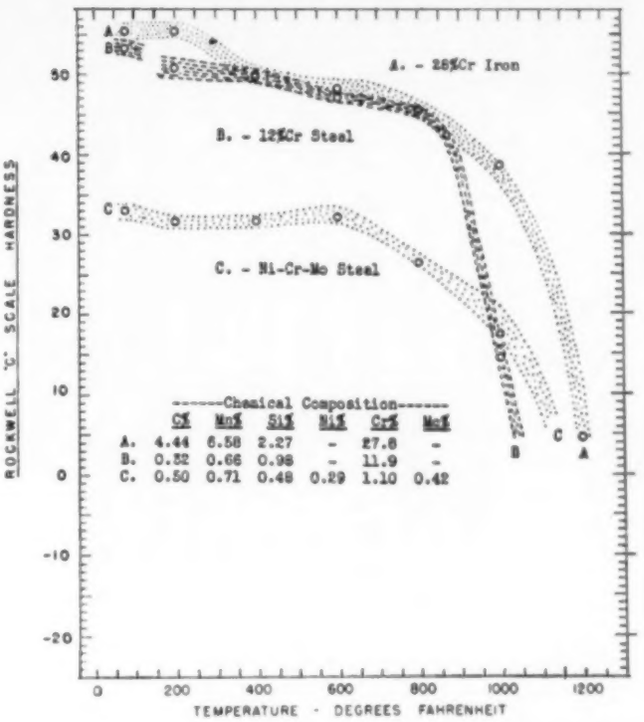


Figure 21 — The effect of temperature on the instantaneous hardness of three iron base alloys. The specimens were cut from small castings and tempered 24 hours at the indicated temperatures before testing. The plotted points are averages of five tests.

ance of the martensitic irons is superior to that of the steels. Otherwise the logic of using them for impact service where abrasion may occur is not clear. The irons with their low melting points are also easier to gas weld than steels.

A laboratory demonstration of the difference in behavior of several alloys appears in Figure 19. Note the low rate of deformation of the strong martensitic iron (this is a chromium-tungsten type). However, the impact blows (500 ft lb each) are too severe, since they produce minute plastic deformation each time. These increments of flow finally cause failure. The martensitic steel was less resistant to flow but permits more plastic deformation. It had not failed up to the limit of the test. The manganese steel specimens deformed rapidly at first, but as work hardening occurred, they became progressively stronger until deformation from further blows appears negligible. The most important industrial application of this behavior of manganese steel is in railway trackwork.

Need for abrasion resistance and tensile impact resistance together usually forces a compromise on the engineer, since they are likely to be opposing properties in a material. One measure of tensile toughness is a merit number derived from the product of ultimate tensile strength and elongation. These indices of toughness are plotted against resistance to grinding abrasion in Figure 20 to illustrate the status of a group of engineering alloys roughly paralleling the classification in Table II. The relatively good combination of properties exhibited by the austenitic manganese steels explains why this type of material is a favorite for impact combined with abrasion.

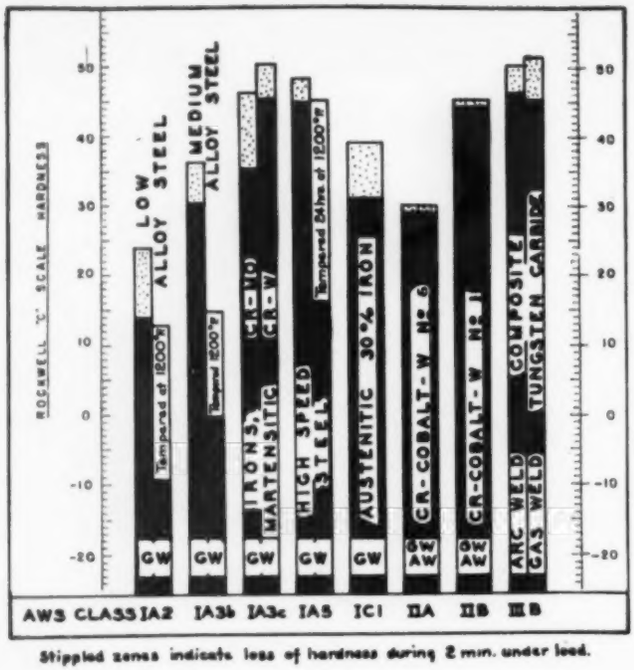


Figure 22 — Apparent hot hardness of hard surfacing alloys at 1000 F.

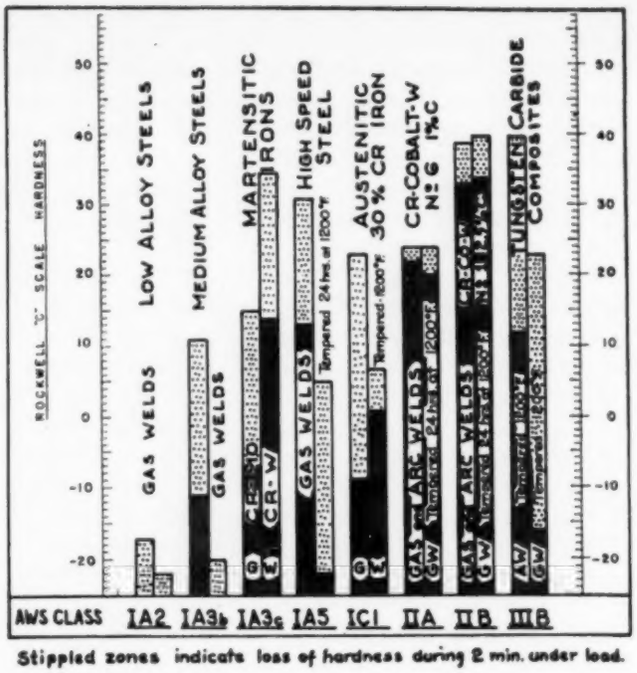

ROCKWELL "C" SCALE HARDNESS
LOW ALLOY STEELS
MEDIUM ALLOY STEELS
MARTENSITIC IRONS
HIGH SPEED STEEL
AUSTENITIC 30% CR IRON
CR-COBALT-W Nº 6 1%C
TUNGSTEN CARBIDE COMPOSITES
AWS CLASS IA2 IA3b IA3c IA5 IC1 IIA IIB IIIB
Stippled zones indicate loss of hardness during 2 min. under load.

Figure 23 — Apparent hot hardness of hard surfacing alloys at 1200 F.

Heat can cause metal deterioration from several angles. It may through oxidation and scaling lead to surface metal loss, growth, and intergranular cracking. It may permanently soften and weaken a hardened steel or iron through tempering or it may temporarily weaken metal through the fundamental softening that is basically related to higher temperatures[6] Figure 21).

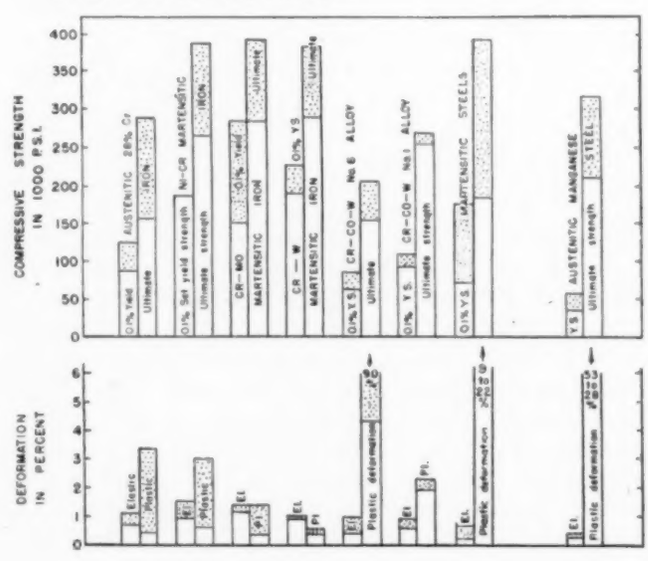
Oxidation—Oxidation and scaling are likely to be associated with hot operations, as in furnace parts or hot metal handling equipment. A simple rule of wide applicability is to provide a minimum of 25 per cent chromium if the alloy must resist oxidation.[7] Nickel ordinarily can be substituted for chromium in a 3:1 ratio. This aids development of a scale that is protective to 1800 F or above if fluxing agents such as lead, sodium, vanadium and kindred oxides are not involved. Since the high chromium irons, the cobalt base alloys and many stainless steels contain 25 per cent or more of chromium they should receive first consideration for oxidation resistance.[8]

Tempering — Tempering effects are minimized by pretempering at or slightly above the service temperature. Extra hardness can be obtained from alloy steels and irons containing chromium, molybdenum, vanadium, and tungsten, which confer secondary hardening properties in the range from 900-1100 F. High speed steels, used as welding alloys, serve well up to 1050 or 1100 F, especially since oxidation is not a serious problem below 1100 F.

Creep—Creep or plastic flow becomes an important factor above 1000 F. Up to 1200 F, martensitic irons may have adequate creep resistance, but at and above 1200 F, the cobalt base hard facing alloys seem to provide the highest hot strength under sustained loads. These factors have been discussed in more detail elsewhere.[6]

In design, the nominal operating temperature is important, but it is also imperative that the momentary high temperatures at friction faces be considered. Frequently, the softening these cause may dominate the wear pattern encountered. Unfortunately such temperatures are difficult to estimate or measure, and the engineer must resort to guesswork. Since the heat developed is likely to be unexpectedly high, it is conservative to provide for frictional heat by alloys with good hot hardness characteristics. Figures 22, 23 will aid in selecting appropriate alloys. Below 600-800 F and above 1200 F, the choice is not usually difficult. From 800-1200 F, there is much room for good judgment and critical selection, balancing probable performance against alloy and welding costs.

Figure 24 — Comparative compression properties of various hard surfacing alloys.



Because of the likelihood that elevated temperature may complicate steel mill problems, individual charts of temperature vs. Rockwell hardness are included under the important alloy types. Figures 22 and 23 will serve as quick selection aids, and the other graphs can be consulted for more detailed information.

Corrosion—Corrosion is not a factor that usually leads to selection of a hard facing material, but in exceptional cases it is expedient to face a container or other part with stainless steel or some other corrosion resistant alloy. The alloy should be ductile and otherwise should be selected after a careful study of corrosion data that cannot be included here, though some leads may be obtained from Table VII.

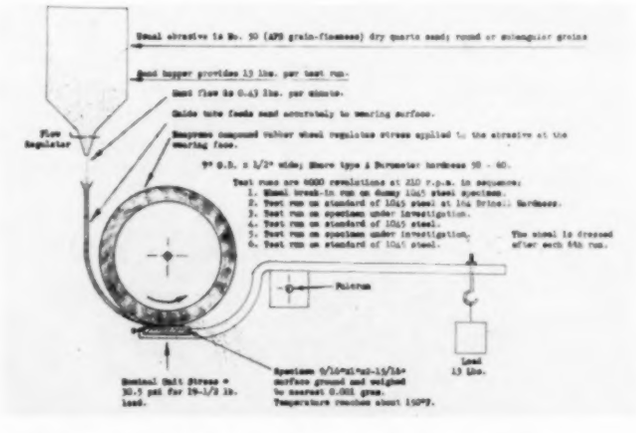
Where carbon influences corrosion rates, gas welding should be used cautiously, because of the expected carbon pick-up. Arc welding is better in this respect but the weld metal will be mixed with or diluted by the base material. This should receive consideration, and the electrode selection should provide an excess of the elements that protect from corrosion in order to compensate for the dilution.

Friction—Friction from metal to metal wear is one of the commonest of engineering problems. Lubrication is the first line of defense, but where it fails or loses much of its effect, as in so-called boundry conditions, the properties of the metals in contact become important. The damage from friction is believed to be due to welding. Wiping contact removes surface films, dirt, oil, gas layers, etc., that prevent true metal to metal contact. When clean faces finally touch, they weld together from the forces of atomic attraction. The smoother the surfaces, the greater the possible area of welding. Low yield strength or the softening from heat also aid in producing intimate contact by increasing the area because of deformation under load.

Where contacting under frictional conditions is relatively slight because of roughness, welding may be unnoticeable. However, if the contact faces are loaded, the resulting deformation can increase the welding areas to the point where obvious seizing or galling occurs. Anything that aids the load to produce more contact may increase such welding. Low yield strength, either because it is initially low or because this property falls as temperature rises, is a frequent offender.

Hard facing, by providing high yield strength at the wearing face, can reduce welding wear. Not all wear resistant alloys have high elastic strength, however, and the material must be properly selected. The compressive properties of several types appear in Figure 24.

Figure 25 — Schematic diagram of dry sand erosion machine.



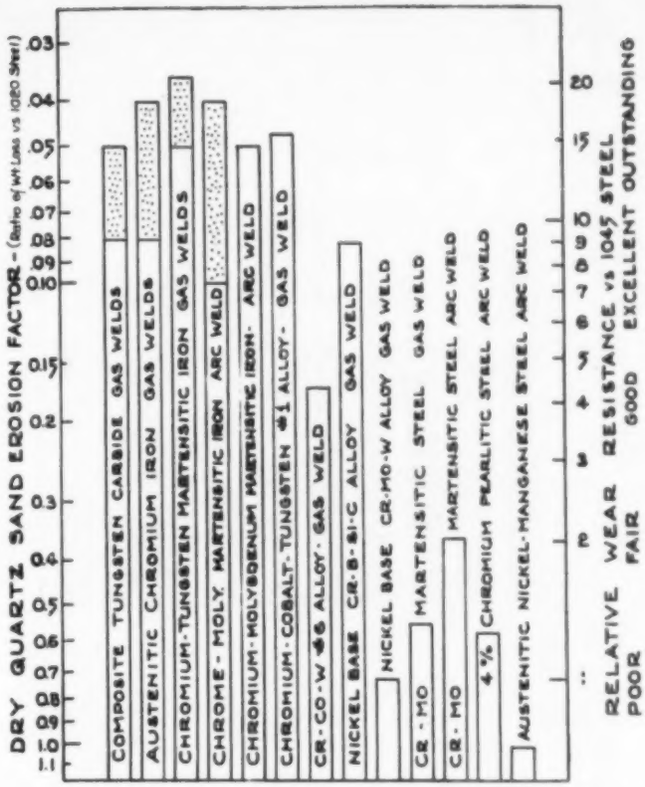


Figure 26 — Relative erosion resistance of hard facing alloys against dry quartz sand.

The welding responsible for seizing and galling may be prevented by films thick enough to hold the metallic faces several millionths of an inch apart. Aluminum oxide is such a film material. It forms readily on aluminum bronze, is tenacious, and if removed is promptly renewed in an oxidizing atmosphere. So tenacious and effective is this oxide that it is not practical to weld aluminum bronze with an oxyacetylene flame. The preferred methods employ an inert gas shielded arc or an electrode that contains powerful fluxing agents.

Aluminum bronze electrodes, while they do not produce particularly hard deposits, thus are useful facing alloys. They can be used as overlays to work against dissimilar hard alloys as well as for die protection and the like.

Abrasion—Abrasion is one of the most severe causes of wear. Because of its complexity, the development of standardized tests has been retarded. However, enough is now known to permit a reasonably accurate outline of several distinct types.

It is convenient to subdivide this wear factor into (1) erosion, or scratching abrasion, (2) grinding abrasion (which is implied herein when not otherwise defined), and (3) gouging abrasion. The first two are differentiated by the stress that can be brought to bear upon the abraded surface. The third is characterized by anchorage or good support of the cutting agent, much like that for a machine tool cutting bit.

While it is possible to obtain good combination prop-

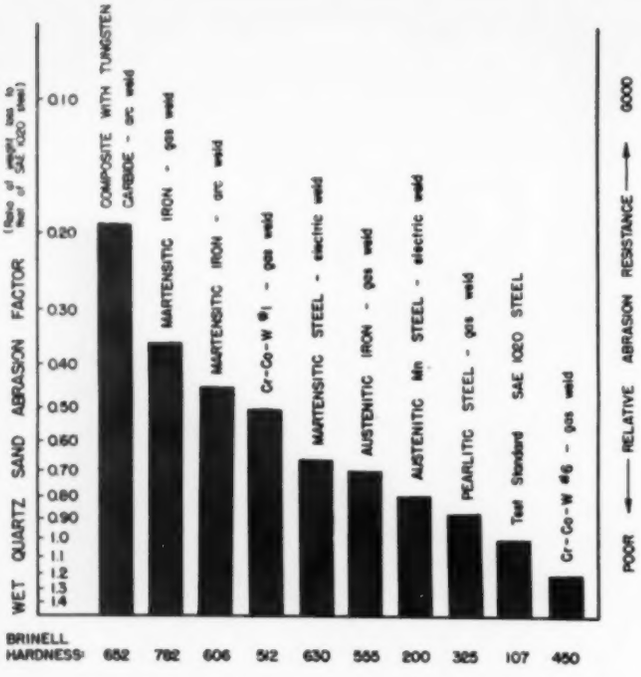


Figure 27 — Relative abrasion resistance of hard surfacing deposits.

erties, the wear resistance of alloys to these three types does not follow a simple pattern. The three must be treated as separate cases in both wear analysis and alloy selection. The factor of impact frequently complicates them and is particularly likely to accompany gouging abrasion.

Erosion—Low stress scratching abrasion will here be termed erosion for simplicity. It ordinarily depends on hard and usually sharp particles for operation.* Increased velocity, greater abrasive hardness, and sharper cutting edges increase its severity. The volume of the abrasive, or stated differently, the relative number of particle contacts, will be a major factor in the rate of metal removal.

Liquid abrasive slurries or airborne "dust cloud" streams have been used to simulate service erosion.

* Erosion can be produced by clean fluids such as water or wet steam, as in hydraulic mining or on steam turbine blades. This type, where fluid velocity is the cause of stress, will be omitted from this discussion.

However, perhaps the best current test technique employs a rubber wheel to carry the abrasive against the wearing face. The rubber performs an important function: it yields and cushions the abrasive so the stress applied is held to a low level. Characteristically this stress is too low to crush the abrasive and as a result, even if the abrasive is reused, its cutting character is little modified.(9), (10)

One such device is illustrated in Figure 25. In practice, after dressing the wheel smooth, a conditioning run is followed by a five-layer sandwich that brackets two test runs on a specimen under investigation between three runs on a standard material. Two wheels are used to speed operations, but they are used for independent tests.

Results from wear tests can be reported in several ways. A fundamental approach provides data in terms of depth of metal removed per unit of time. This requires density and area measurements as well as time and weight loss values. However, perhaps the most serious objection to such a system is the difficulty in translating it into service performance unless comparative values are available.

Experience has tended to favor a comparison method of reporting, by means of a ratio against some standard material, although surface loss per unit of time is widely used for liquid and hot gas corrosion where areas are easily defined. The abrasion factor or ratio method can emphasize either wear or wear resistance, depending on the trend of an individual's thinking. One is the reciprocal of the other and they can be readily converted. Herein, wear is emphasized so that small wear factors mean slight wear or weight loss. The reciprocal merit ratio evaluation is served by inverting the wear factor scale in graphic plots, so the height of a bar, as in Figures 1, 3, 12, 26 and 27 indicates relative merit or wear resistance.

Comparative data from the dry rubber wheel erosion test are given for representative hard facing types in Figure 23. The ranking from such service conditions as plowing in sandy soil, foundry sandslinger parts, and wheelabrator blades correlate with these data. However, the wear ratios may vary considerably. Experience suggests that mild conditions will create a much greater spread in apparent wear resistance than will severe service.

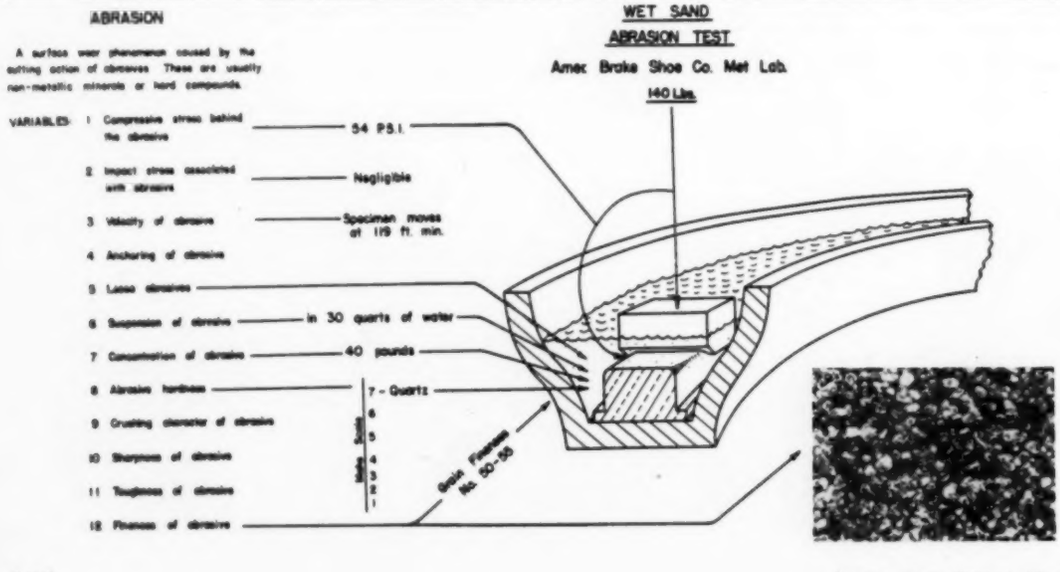

ABRASION
A surface wear phenomenon caused by the cutting action of abrasives. These are usually non-metallic minerals or hard compounds.
VARIABLES:
1 Compressive stress behind the abrasive
54 P.S.I.
2 Impact stress associated with abrasive
Negligible
3 Velocity of abrasive
Specimen moves at 119 ft. min.
4 Anchoring of abrasive
5 Loose abrasive
6 Suspension of abrasive
in 30 quarts of water
7 Concentration of abrasive
40 pounds
8 Abrasive hardness
7 - Quartz
Mohs Scale
9 Crushing character of abrasive
10 Sharpness of abrasive
11 Toughness of abrasive
12 Fineness of abrasive
Grade Fineness No. 50-60
WET SAND
ABRASION TEST
Amer. Brake Shoe Co. Met. Lab.
140 Lbs.

Figure 28 — Sketch shows schematic diagram for wet sand abrasion test.

Quartz sand was selected for the test because it is the commonest abrasive present in nature. It is undoubtedly the greatest cause of abrasive wear, even though its operation may not be obvious. Iron ore, for example, is likely to owe much of its abrasiveness to the siliceous matter present, since quartz in all of its manifold varieties is harder than the iron oxides.

If abrasives other than quartz are involved, it is reasonable to expect greater spreads in performance if they are softer, but associated with lower wear rates, while harder abrasives will abrade all of the materials more rapidly at rates that reduce the spread between alloys.

Unless tungsten carbide or the chromium-tungsten hard facing in Figures 9 and 12 is selected, the engineer should decide whether erosion or abrasion is most important. For erosion the high chromium irons are excellent; for high stress abrasion martensitic iron is a better choice. Both of these cost about the same and are less expensive than tungsten carbide, which is outstanding against both types of wear.

Grinding abrasion—High stress abrasion[1] usually results when particles are caught under pressure between two metal faces. Even with low nominal loads on the metal portions of this sandwich, the unit stress in the abrasive, and consequently on its metallic contact areas, may be very high. These stresses crack or crush the abrasive grains. The broken edges are sharp and can scratch efficiently. Moreover, the concentrated stress on the metallic face can disrupt the metal or fragment some of its micro constituents. Deterioration then occurs from scratching, from local plastic flow, and from micro cracking.

The presence of high stress abrasion can be deduced from observation of a metal sandwich as described and from the fact that an abrasive is crushed or ground. Ball milling is an excellent example. [11] [12]. In steel mills such conditions may be looked for where machine parts rub in a gritty environment.

The laboratory apparatus [1] [10] [13] [14] for producing this abrasion is shown in Figure 28, and representative data are graphed. Note that the spread in performance between good and poor materials is less than for the low stress abrasion, reflecting the relatively severe conditions of the high stress test.

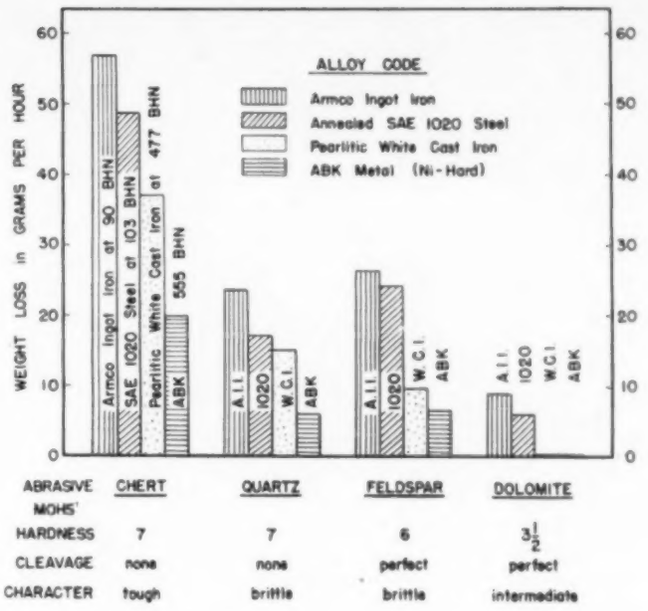


Figure 29 — Relative abrasiveness of common mineral abrasives, using as a criterion metal weight loss.

The hardness and character of the abrasive are important variables. The relative abrasiveness of several minerals in comparison with quartz sand is shown in Figure 29. Fortunately, quartz is so common that the different pattern caused by other abrasives is not a frequent complication in service.

Gouging abrasion—Both of the conditions just described have in common a loose abrasive. It is free to roll or skid, and can flow around or undermine a hard alloy constituent. Such abrasives cause shear, tensile, and compressive stresses in the wearing face.

Gouging abrasion seems to be associated with a fixed stress producing point. A lathe tool is an example and machining possibly can be termed a related type of wear. A sharp boulder that gouges a dipper digging iron ore is a familiar field occurrence, producing deep scratches and gouges, on the metal part. Note the implication of impact in the dipper example. On a minute scale the same thing happens when metals are ground by an abrasive wheel, the fixed abrasive cutting grooves

TABLE XIII

HARD FACING ALLOY SELECTION FOR IMPACT SERVICE

Material	Martensitic irons*	Martensitic steels*	Austenitic manganese steel
Suitable for	Light impact	Medium impact	Heavy impact
Yield strength, tensile, psi	60,000 to 80,000	60,000 to 80,000	45,000 to 55,000
Ultimate tensile strength, psi	65,000 to 90,000	60,000 to 125,000	100,000 to 150,000
Tensile elongation per cent	0.01-0.04	0.01-0.10	30-70
Brinell hardness	500-750	500-750	160-220
Rockwell hardness	C48-C65	C48-C65	CO-C20
Yield strength, compressive—0.10 per cent set, psi	150,000 to 285,000	76,000 to 175,000	45,000 to 55,000
Ultimate compressive strength, psi	265,000 to 385,000	180,000 to 385,000	200,000 to 310,000
Elastic deformation, per cent	0.8-1.4	0.8-1.5	
Plastic deformation, per cent	0.2-5.4	1.0-22	30-55
Total deformation, per cent	1.2-6.5	1.8-23	
Wet sand abrasion factor**	0.30-0.50	0.65-0.80	0.75-0.85
Dry sand erosion factor**	0.05-0.15	0.15-0.55	0.55-1.00

*Untempered, corresponding to the usual status of weld deposits.
**Weight loss ratios compared with annealed SAE 1020 steel.

in the metal. Do not confuse this grinding with the grinding abrasion previously described. A grinding wheel is actually a machining tool.

Alundum grinding wheel abrasion tests data are available, but because they have not yet been correlated with field service, they are not reproduced here. In general tungsten carbide is best, high chromium irons are next, and the martensitic irons follow. Were it not for the associated impact, this trio would be preferred. However, except where they are protected from shock deformation, their brittleness is too great for good life expectancy.

Austenitic manganese steel is the most difficult of the ductile alloys to machine. It is also the toughest. It is frequently typed as commercially unmachinable except by grinding. It can be cut by tungsten carbide or top quality high-speed steels in heavy, rigid equipment. It requires more energy to cut it than does any other soft metal (the work hardening in cutting does not increase hardness to the level of some more easily cut alloys) and perhaps significantly, it absorbs more energy for a given amount of impact deformation than any other common metal. Independently, field experience has accorded it the preferred position for wear resistance to gouging abrasion that occurs in all sorts of mining, crushing, and grinding equipment. It is, therefore, selected where wear resistance plus toughness is required.

THE BASE FOR HARD FACING

While most metallic structural materials can be hard faced, the weldability of the base is an important consideration. Deposition upon a base of much lower melting point is likely to be difficult or unsatisfactory. Ordinarily, this is not a problem since most facings are put on iron or steel, the latter generally being best if the engineer has freedom of selection.

A preferred grade is 1045 killed steel, which is relatively strong but fairly free from cracking tendencies. If even greater strength is required, a eutectoid steel with around 0.80 per cent carbon can be used, but will require more careful handling. Low carbon mild steel like the 1020 grade may weld easily but often is too weak.

The alloy steels, especially with medium or high carbon content, are difficult to weld without cracking and should be avoided if possible. If they must be welded, a pad of austenitic stainless steel, like 25 per cent Cr:20 per cent Ni, arc deposited from a lime coated electrode, can help minimize cracking. In any case it will pay to examine the time-temperature-transformation curve for the base steel involved and to control heating and cooling to cause a pearlitic transformation. Simple steels are unlikely to form martensite unless quenched, but many of the alloy steels, particularly if they pickup carbon during welding, are able to form martensite as the weld cools. Formation of martensite causes expansion and the associated stresses, especially near room temperature, are a common cause of cracks. Hydrogen, in the steel or picked up during welding, accentuates the tendency toward cracking.

The base steel should be killed and of good quality since weld defects are sometimes traced to non-metallic impurities or to inadequate deoxidation. The surface should be prepared to be free of oxides, grease, oil, or other foreign material. The usual method is to grind the area to be faced.

CONCLUSION

This paper has emphasized salient properties of hard facing alloys and facts that will aid on-the-spot wear analysis.

In using this background it is suggested that the impact factor be considered first, evaluating both its severity and the competency of the base material to withstand deformation. This should lead to a decision, guided by Table II, as to whether austenitic steels, air hardening types, or the brittle but more abrasion resistant grades can be employed.

Figure 30 — Ingot tong bits in soaking pit service. The temperature at the contact point, the high stress, and the fact that the stress may be sustained up to several minutes make hot hardness and creep strength important properties of the alloy used to protect the contact area.

The maximum temperature of service, and the duration of load application should next be estimated and the best materials in Figures 22 and 23, that also meet the impact requirements, examined. The appropriate detailed chart given under the discussion of these alloys should also be consulted. If the demand for strength is not great, but oxidation resistance is required, examine the alloys with 25 per cent or more

chromium. If both high hot strength and hot gas corrosion at 1600 F or higher are needed, the field is narrowed to the chrome-cobalt-tungsten alloys. These are likely to become scarce, and while substitutes are becoming available, technical data to assist in selecting them are scanty.

Ingot tong bits are an example of service where hot strength and creep resistance are needed (Figure 30). The ingots at around 2250 F will rapidly heat the bits to well above 1200 F into the range where cobalt base alloys excel. The stress on the bits is sustained up to several minutes, making the short term creep strength, as indicated by the time factor points on the hot hardness charts, perhaps more important than high initial hardness. The logic of selecting the 1.0 per cent C Cr-Co-W alloy is obvious.

These bits may also be called upon to handle colder ingots or molds where a different set of properties is desirable. However, if the bits are not cooled before such service, the harder cold metal will tend to deform and blunt the hot and therefore softened bits. This is usually avoided by water quenching the tong tips when they become too hot. Note that service involving heating and quenching will tend to crack the iron base alloys that can transform from austenite to martensite, operating thus to eliminate the martensitic types, though they would be better if only cold service were in prospect.

Since cobalt base alloys have so many other strategic uses, substitutes will be welcome. In trying such alloys, in general an austenitic structure for creep strength and cracking resistance; ample chromium for oxidation resistance; and enough carbon to contribute hardness and wear resistance, should be considered essential. Some of the chromium-nickel irons and steels meet these criteria and have performed successfully in hot wear applications, but the level of performance may not equal that of the more expensive cobalt base alloys.

Another type of hot wear is illustrated in Figure 31, where guides for a bar mill are subjected to heat, friction and abrasion. Impact is not great enough to cause concern. Frictional wear of the welding type is inhibited by the oxide surface on the bars, which minimizes direct metal to metal contact. However, iron oxide is abrasive. An additional wear factor, thermal fatigue, is also present. This is too complex to discuss in detail [14] [15] [16] and moreover its operation is less obvious than most wear mechanisms. Briefly, it occurs from a sequence of heating, a build-up of compressive stress because of thermal expansion, hot upsetting (plastic flow) beyond a critical stress, subsequent cooling with thermal contraction and rising tensile stress in the upset portion, and eventually tensile cracking because lower temperature ductility is exceeded. Time and temperature relations control the number of cycles required to produce either excessive deformation (usually evidenced as warping) or small scale cracking. This cracking is characteristic of thermal fatigue. Another familiar steel mill example is crazing of ingot mold interior surfaces after long use.

Thermal fatigue cracking does not necessarily destroy the usefulness of a part. Hard faced areas, provided the segments are securely anchored to a competent base, can serve well even when severely cracked.

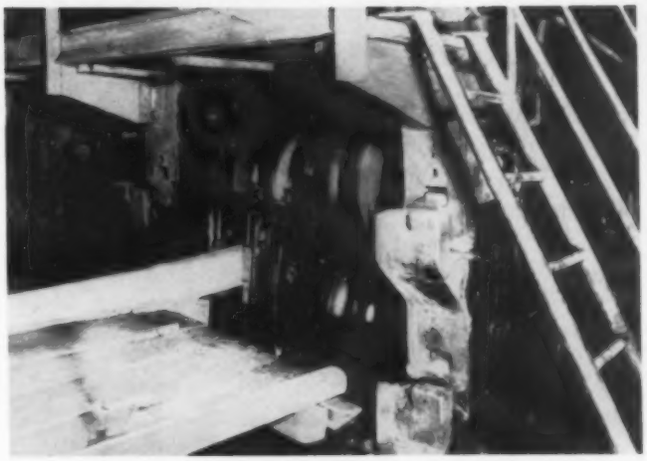


Figure 31 — Hot bar mill service for hard faced guides. Friction, oxidation, softening from elevated temperatures, and thermal fatigue are all wear factors affecting the hard facing alloy. Of these the thermal fatigue mechanism is probably most important.

These mill guides exemplify this. Spalling is considered serious, but cracking is not. In Figure 32 both guides are faced with an austenitic high-chromium iron. The normal life of an unfaced guide is 1200 tons of steel processed. Those in Figure 32 have handled about 63,000 tons.

Our present knowledge of thermal fatigue, which is relatively scant, suggests that a combination of hot strength, cold ductility, low thermal expansion, and high thermal conductivity are helpful in resisting the eventual cracking. Since the hot strength and ductility of alloys varies considerably with both temperature and composition, the maximum temperature obtained is important. In the case of the guides illustrated it was not high enough to provide the marked advantage that would be obtained by the cobalt base alloy at, say, 1800 F. An advantage of the chromium iron, with its hard carbides is better abrasion resistance.

The 1 per cent carbon cobalt base alloy (No. 6 type) is a standard hard facing for this application, yet substitution of a less expensive material has been satisfactory. There are many places, such as this, where economies or relief from shortages can be achieved through closer analysis of the service conditions and judgment in alloy selection.

Figure 32 — The worn faces of the bar mill guides shown were hard surfaced austenitic high chrome iron. Service life was about 63,000 tons of bars handled.

If corrosion is involved, the subject should be studied carefully in other references, since this is perhaps the most complex field of wear resistance. Fortunately, aside from pickling operations, steel plants have relatively few severe corrosion environments.

If frictional wear is involved, impact is likely to be light or moderate. Temperatures are difficult to estimate, but if lubrication is absent or if it fails, the possibility of rising to 800-1000 F should be considered. Martensitic irons or steels containing chromium, molybdenum or tungsten can aid here, the choice being narrowed by impact conditions.

If stresses are not too high, aluminum bronze as a mating surface alloy should be considered.

Next, abrasive conditions should be examined and the type of abrasion tentatively identified. If abrasion is obviously the major factor, it may be considered second after evaluation of impact conditions. Unless impact is severe (requires austenitic alloys) the type of surface that can develop in use may be important. If a polish, with relative absence of roughness and surface teeth, is desirable, the tungsten carbides deposits may not be practical. Otherwise they may be the best for abrasion resistance. With them some latitude in terms of toughness and hot hardness is possible by the selection of granule size and welding method.

The austenitic and martensitic irons polish well, and being less expensive than tungsten carbide they are frequently selected for resistance to abrasion. The choice between them should be based on the identification of erosion vs abrasion (or low versus high stress abrasion.) If hot hardness as well as abrasion resistance is required, the chromium-tungsten martensitic iron may be indicated. Finally the tentative selection should be reviewed in relation to shut down costs and overhaul schedules. If life expectancy is obscure, the trial of two or three types, to obtain base line data, should be made for the same installation. The most economical choice will probably be that which lasts just through the normal service interval, or for some multiple of this. There is little advantage if one alloy can outwear another by 50 per cent, for example, if the base line life is one service period, because the better alloy would need replacement at each overhaul, anyway. If life were doubled by a 100 per cent improvement, however, a real saving can be shown even at considerably greater alloy cost, because replacement need be made only during every other shut-down.

A larger user of hard facing alloys will undoubtedly encounter or hear of specific materials that have done well in steel mill applications. An examination of the facts will usually disclose that the combination fits into the pattern outlined in this paper, provided the composition and structural type of the hard facing alloy can be identified.

If the logic of an alloy-application combination is not clear, it may be the result of either an exception to the picture presented here or of a misapplication. The simplification attempted here has necessarily involved omitting a modest area of the hard facing field. On the other hand, there have been many mistakes in the use of hard facing alloys, and a careful scrutiny of an established practice may lead to rewarding changes.

BIBLIOGRAPHY

1. Avery, Howard S., *"Some Characteristics of Composite Tungsten Carbide Weld Deposits,"* Welding Journal, Vol. 30, No. 2, Feb. 1951, pp. 144-160.

2. Avery, Howard S., *"Austenitic Manganese Steel,"* published by American Brake Shoe Co., New York City, 1949, (A somewhat condensed version appears in pp. 526-534 of the 1948 Edition of the A.S.M. Metals Handbook).

3. Avery, Howard S., *"The Metallurgical Background for Welding Austenitic Manganese Steel,"* published by American Brake Shoe Co., New York City, 1949.

4. Avery, Howard S., *"Hard Surfacing by Fusion Welding,"* American Brake Shoe Co., New York, 1947.

5. Timoshenko, S., *"Theory of Elasticity,"* pp. 385-394, McGraw-Hill Book Co., 1934.

6. Avery, Howard S., *"Hot Hardness of Hard Facing Alloys"* Welding Journal, Vol. 29, No. 7, July 1950, pp. 552-578.

7. Avery, Howard S., *"Estimation of Scaling Resistance,"* Alloy Casting Bulletin, No. 10, May 1947.

8. Brasunas, Gow and Harder, *"Resistance of Iron-Chromium-Nickel Alloys to Corrosion in Air at 1600 F to 2200 F,"* Proceedings ASTM—Vol. 46, 1946 and included in the ASTM "Symposium on Materials for Gas Turbines."

9. Haworth, R. D., Jr., *"The Abrasion Resistance of Metals,"* Trans. ASM, Vol. 41, pp. 819-854, 1949.

10. Avery, Howard S., Discussion of *"Abrasion Resistance of Metals,"* Trans. ASM, Vol. 41, pp. 854-860, 1949.

11. Norman, T. E. and Loeb, C. M., *"Wear Tests on Grinding Balls,"* A.I.M.E. Tech. Pub. No. 2319, Metals Technology, April 1948, A.I.M.E. Transactions, Vol. 176, pp. 490-520, 1948.

12. Avery, Howard S., Discussion of *"Wear Tests on Grinding Balls,"* A.I.M.E. Tech. Pub. No. 2448, Transactions A.I.M.E. Vol. 176, pp. 521-523, 1948.

13. Blake, J. M., *"Wear Testing of Various Types of Steel,"* Proc. A.S.T.M., Vol. 28, Part II, pp. 341-355, 1928.

14. Avery, Howard S., and Matthews, N. A., *"Cast Heat Resistant Alloys of the 16 per cent Cr: 35 per cent Ni Type,"* Trans. A.S.M., Vol. 38, pp. 957-1015, 1947.

15. Avery, Howard S. and Wilks, Charles R., *"Cast Heat Resistant Alloys of the 26 per cent Cr: 20 per cent Ni Type—Part I."* Trans. A.S.M., Vol. 40, 1948, pp. 529-577.

16. Avery, H. S. and Wilks, C. R., *"Alloy Casting Institute Thermal Fatigue Testing,"* Alloy Casting Bulletin, No. 14, May 1950.

DISCUSSION

PRESENTED BY

JAMES J. HEALY, Project Engineer, Armco Steel Corp., Middletown, Ohio.

HOWARD S. AVERY, Research Metallurgist, American Brake Shoe Co., Mahwah, N. J.

James J. Healy: Do you have any information regarding what this society or any society is doing in the way of writing a specification for this type of work?

Howard S. Avery: There is a joint committee of the American Welding Association and the American Association of Testing Materials that is working on the problem, which is admittedly a tough one.

Currently they have picked five types which are rather well standardized industrially: the high-speed steel type, austenitic chromium iron, two cobalt base alloys, and austenitic manganese steel types. I think that in the fall, tentative specifications will be formulated. Sufficient detailed specifications should be helpful in minimizing the confusion that may develop during substitution of one type for another during periods of alloy scarcity. Our past changing of alloy content in welding alloys during emergency conditions has not always been technically well grounded.

Laboratory Screening of Multi-purpose Greases

By E. M. KIPP
and
C. A. ZEILER
Aluminum Research Laboratories
Aluminum Co. of America
New Kensington, Pa.

. . . . multi-purpose greases can be evaluated in the laboratory to determine what their performance will be under actual operating conditions . . . .

▲ MULTI-PURPOSE greases are commercially available which offer certain advantages, particularly to the large consumer. Their use permits economy in inventory and purchasing, and for many applications may increase performance with no over-all increase in cost.

The selection of a multi-purpose grease presents a number of difficulties. Plant performance tests would be a practical answer were it not for the fact that they are often time-consuming. Moreover, the variety of applications in which a multi-purpose grease must serve may be so numerous as to make a plant performance test rather impractical, particularly if many greases are to be examined. An attempt has been made to find a solution for this problem in the laboratory by selecting a number of different types of laboratory test procedures. Each grease is given a relative rating by each of these test procedures, and the over-all merits of the grease are obtained by the summation of the results recorded in the individual test procedures.

Specifically, ten different types of test are employed in the laboratory screening of a grease product. The general nature of these tests will be individually summarized and the method of using the test results in these laboratories will be reviewed. Of course, when a plant application with special requirements is under consideration, the test schedule employed may be modified to take account of the particular service requirements which it will meet.

TEST SCHEDULES

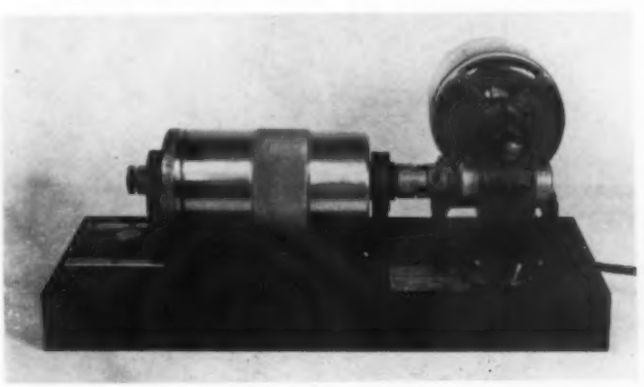
Motorized grease worker—The Precision Scientific Co.'s motorized grease worker provides a method for evaluating the tendency for changes to occur in the consistency of a grease when it is subject to varying degrees of mechanical "working" by the grease worker. The changes in consistency of the grease are measured by the ASTM Penetration Tests[1]*. The penetration values of the grease are normally measured on the sample as received (unworked penetration) and after intervals of 60 strokes and 10,000 strokes of working in the grease worker.

It is assumed that the grease product as received is suitable for its intended application and, therefore, that it is desirable for the grease to retain its properties under working conditions with as little change as possible. If a grease hardens or softens excessively during the test, this is assumed to be an indication of poor stability. Therefore, the grease with the minimum change in consistency after working to the extent of 10,000 strokes is given a preferred rating.

Shell roller — The shell roller test is another device for "working" of a grease under conditions involving high rates of shear.[2] Basically, this test "works" the grease by kneading it in a rotating housing containing a closely fitting weighted roller. The penetration is

*Numbers refer to bibliography at end of article.

Figure 1 — Shell roller test apparatus measures a change in penetration.



measured before and after the test using a special, light, micro cone penetrometer. The grease with the minimum change in penetration is given the highest rating for this test. It may be interesting to note that this test appears to be more severe in producing changes in consistency of the grease under test than is the grease worker test.

Dropping point — The dropping point test indicates the temperature at which a grease passes from the plastic to the fluid state and is conducted in accordance with the procedure specified by the ASTM[3]. The grease having the highest dropping point is rated as superior in the evaluation of our samples.

In the interpretation of this test, it is realized that a dropping point temperature of 400 F, for example, does not necessarily indicate successful performance of the grease at temperatures below this figure. When applying this test in the selection of multi-purpose greases, it is desirable that the greases function under as wide a range of temperature as possible. For this reason, preference is given to a grease showing a high dropping point value, as the grease will not remain a grease at temperatures above this value.

Bleeding and evaporation — The procedure for the bleeding and evaporation test follows methods developed by the National Defense Research Committee[4] and is a part of the AN-G-3A specification for low temperature greases. This test is intended to indicate the extent to which a grease will lose oil by "bleeding" of the oil from the grease and by evaporation of the oil component. This test is conducted as follows:

Figure 2 — Wheel bearing test apparatus evaluates grease lubrication in wheel bearings.

A weighed sample is placed in a small screen cone, which in turn is supported in a clean tared beaker. The assembly is placed in a gravity convection oven and maintained at temperature for a specified period. The loss in weight of the combined unit gives a measure of the evaporation of the grease, while the increase in the weight of the beaker gives the amount of bleeding that has occurred. The grease showing the least amount of bleeding is given a rating of 1, the second best 2, the third best 3, etc. In a similar manner, the greases are rated with respect to their evaporation losses. The two individual ratings for a given grease are combined, and the test rating computed on the basis of the resulting sum.

Again, in the interpretation of these test data, it is necessary to keep in mind a number of factors. For example, it is recognized that there are cases where the ability of a grease to exude or bleed oil in a controlled manner is of definite merit. However, it is also recognized that numerous practical difficulties would arise if it were necessary to depend upon a rate process such as controlled bleeding for optimum lubrication. A pertinent point would be the question as to the change in properties of the grease as it loses oil at a controlled rate, and the problem of synchronizing these changes in properties with additions of make-up grease or actual cleaning of the bearings and repacking with new grease. Therefore, it is preferred, if possible, that the grease in the as-received condition be able to lubricate satisfactorily without having to rely upon substantial amounts of bleeding of oil. For these reasons, a preferred rating is given to those greases showing the greatest resistance to change in properties by bleeding or evaporation.

Wheel bearing — The primary purpose of the wheel bearing test is to evaluate the suitability of a grease for use in automotive type wheel bearings. A detailed explanation of the procedure used may be found in a report issued by the CRC.[5] The greases are rated Pass A, Pass B, or Fail, depending upon the amount of leakage from the rear bearing, condition of the bearings after test, condition of the grease after test, and the change in consistency of the grease during the test.

This test is looked upon as a means for obtaining some idea as to the ability of a grease to lubricate a bearing at moderately high temperatures and speeds, with particular reference to leakage from bearing housings, changes in the properties of the grease itself after the test, and deposition of hard soap residues or other products of high temperature deterioration.

Water leaching — The purpose of the water leaching test is to determine the ability of a grease to resist the leaching action of water. A weighed sample of grease is subjected to a circulating stream of tap water maintained at a given temperature. The stream of tap water impinges through a metal screen directly upon the surface of the grease, and is there collected and recirculated to the grease sample. The entire assembly (with the exception of the pump) is mounted on a hot plate for the purpose of controlling the temperature of the circulating water. After the test has been completed, the grease sample is dried to a constant weight and the loss in weight calculated as per cent of the original weight of sample. This test is prescribed in a Bureau of

Ships' Department of the Navy Specification.[6] The grease showing the minimum loss is given the highest rating.

A preferential rating is assigned to those greases showing minimum losses in this test because of the fact that multi-purpose greases are used in applications where the bearings are subjected to copious quantities of water and soluble oil emulsions in water at rather high temperatures. Those greases which show little or no loss by this test have consistently shown good results in performance where contamination by water is a factor.

Shell four-ball — The Shell four-ball apparatus is a device for obtaining information regarding the load carrying abilities and wear characteristics of lubricants. The four-ball apparatus consists of three contacting steel balls held in a fixed position relative to each other and a fourth ball above and in contact with the other three. The fourth ball is pressed against the three stationary balls with an adjustable force and rotated at a constant speed. The points of contact are lubricated by the oil (or grease) under test in a cup surrounding the four ball assembly. Different loads are applied by varying the position of various kilogram weights on the lever arm. During the test, circular scars are worn in the surface of the three stationary balls. The diameters of the scars are a measure of wear, and depend upon the load, speed, time of test, and character of the lubricant.

This test is considered to provide some indication of the ability of a grease to resist wear under relatively high unit pressures and rubbing speeds. In general, good correlation has been found between the ratings of a grease on the basis of this test and the general performance histories of such greases under field conditions. This test, however, is not thought to be sufficiently significant to warrant specification of a minimum machine rating for a grease in order that it be considered for subsequent field performance testing.

Norma-Hoffman — The purpose of the Norma-Hoffman test is to determine the degree to which a grease will react with oxygen during storage. Greases which are highly susceptible to oxidation are generally undesirable. This test measures the pressure drop that occurs when the grease under test is subjected to an atmosphere of oxygen at a constant temperature for a specified period. This test is conducted in accordance wlth the procedure specified in the ASTM Standards on Petroleum Products and Lubricants.[7] The rating procedure gives the grease with the lowest pressure drop the highest rating for this test.

Water resistance (AN-G-5a) — A test which evaluates the water resistance of a grease as used in service in a bearing exposed to water at any desired temperature is made according to an N.D.R.C. procedure.[8]

In contrast to the previous water test 14-L-5, this test measures the grease loss sustained by a rotating bearing which is almost completely protected by a tight fitting housing. The arrangement is such that a stream of water can enter the bearing through a circular opening $\frac{1}{16}$ in. in width and 1 in. outside diameter. Operation is continued for one hour, after which the bearing is removed and dried to a constant weight. A blank test (procedure the same except that no water is used) is also conducted to determine the grease loss from the mechanical effect of rotation alone.

The blank correction factor is subtracted from the result obtained using both water and rotation, thus giving a value for the grease loss due to the action of water. The grease showing the lowest loss from the bearing due to the action of water alone is judged to be superior.

In many respects this test procedure is perhaps a duplication of the water resistance tests described in the section "Water Leaching," and in fact the correlation between the two types of tests has been found to be excellent. However, this particular test does provide additional information with regard to the tendencies for mechanical losses of grease from actual bearings operating under relatively high contamination by water. Here again, a preferential rating is assigned those greases showing minimum losses resulting from the contamination by water in this test procedure.

High temperature grease beater — The high temperature grease beater is used to study the qualitative changes occurring in grease when the grease is worked at high temperature. It utilizes a ball bearing (1207X1A) which operates in an enclosed chamber at a controlled speed and temperature. The tests in the present work were conducted at a bearing speed of 5000 rpm and a temperature of 300-320 F. After the test has progressed for three hours, the condition of the grease is noted and recorded as being comparable to one of the following consistency states:

1. Softens but retains grease structure.
2. Softens to semi-liquid state.
3. Almost liquid.
4. Entirely liquid.

The grease with the minimum change in structure, as recorded at the three hour observation period, is rated as the best high temperature product.

Figure 3 — Water resistance test apparatus evaluates service of grease in bearing exposed to water.

This test is of considerable value if used and interpreted in general terms. For example, it makes possible the observation of the actual physical condition of a grease under high speed agitation at various temperature levels. Also, it permits the determination of the temperature levels and time intervals at these levels which a grease can tolerate without undergoing undesirable changes in properties.

Another interesting bit of information which can be obtained from this test is that of the tendency for a grease to develop heat through absorption of mechanical energy. In some cases a grease placed in this test unit has been found to attain a temperature of 450 F in the absence of any applied heat. A preferential rating is assigned to those greases which indicate the smallest change in appearance and properties during the test, and again at the conclusion of the test when the grease is allowed to cool again to room temperature. It is thought that such greases are likely to exhibit the most stable physical and chemical properties under actual operating conditions.

APPLICATION OF TEST SCHEDULE RESULTS

The foregoing paragraphs have described the essential features of the various laboratory test procedures employed in our laboratories in the screening of grease products for plant performance testing. This section will briefly illustrate how the individual test results were applied to arrive at an over-all index of probable performance quality.

In Table I are listed the range of experimental values obtained in the water leaching test (14-L-5).

TABLE I

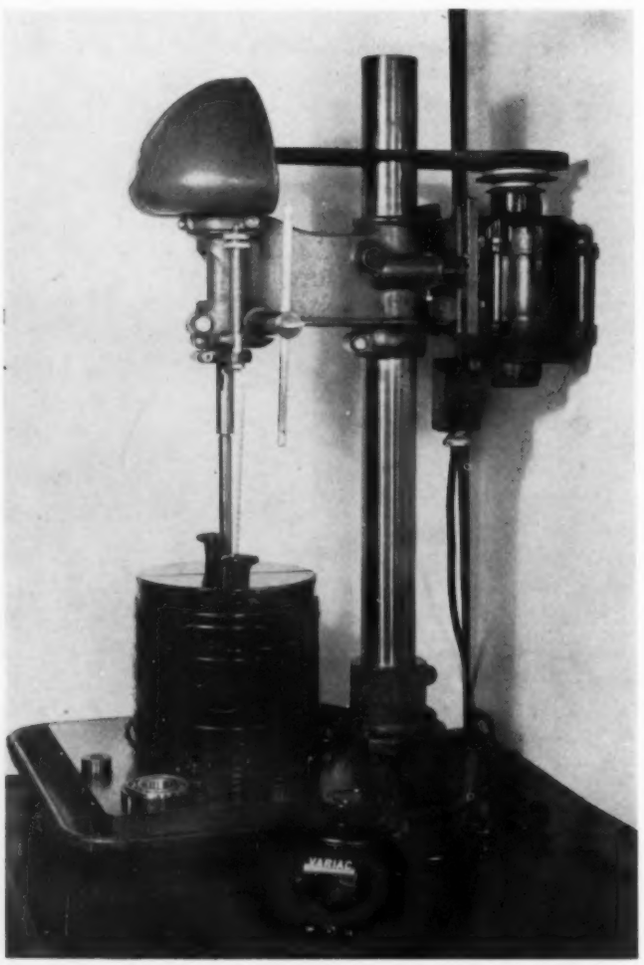
GREASE RATING VALUES — WATER LEACHING TEST (14-L-5)

Experimental results*	Machine rating
0	1
0.1 to 0.2	2
0.3	3
0.4 to 0.5	4
0.6 to 0.9	5
1.0 to 1.5	6
1.6 to 1.7	7
1.8	8
1.9 to 2.0	9
2.1 to 2.2	10
2.3 to 2.6	11
2.7 to 4.3	12
4.4 to 4.6	13
4.7 to 93.0	14
93.1 or over	15

*Per cent loss after 1 hour (140-150 F).

It will be noted that these experimental results are subdivided into a series of incremental ranges. Opposite each range will be found a machine rating — the best rating receiving a value of 1, and the worst rating a value of 15. Thus, the table is used simply by taking the actual experimental result obtained for the particular grease under test and locating from this result the proper increment in column 1 of the table. The machine rating is then found in column 2 directly opposite to the experimental result increment. Similar rating tables have been prepared for each of the tests described in this paper, and in this manner individual ratings for each test procedure are obtained. The overall rating of the grease is then computed by adding each of the individual test procedure ratings. The development of the rating tables must necessarily be a function of experience, training, and consideration of the particular problem at hand. It is naturally expected that as performance data obtained under reliable conditions become available, modifications of the rating tables and simplification or improvement in test procedures can and will be made to good advantage. Nevertheless, it is believed, on the basis of practical experience to date, that this general and empirical method of screening greases for subsequent performance testing has been satisfactory.

Figure 4 — High temperature grease beater test apparatus studies changes in grease at high temperatures.



FIELD PERFORMANCE TESTING OF GREASES

New greases of potential interest, selected on the basis of the foregoing testing procedures, are submitted to the various works of the company for widespread applications in a representative cross section of bearings. Arrangements are made for the use of the new grease for periods of at least six months, unless trouble

is experienced prior to that time. The evaluation of these greases under such conditions is carried out under the supervision of the plant oils and lubricants committee through the proper maintenance, operating, or engineering groups. Operations involving really extreme bearing temperatures or speeds are not encountered in this company. However, there is a wide variety of bearings, and often conditions of severe contamination by water or emulsions with reference to cutting, scalping, grinding, and hot rolling operations are encountered.

One of the most severe high temperature applications employed in the performance evaluation of the laboratory screened greases involves the grease lubrication of trunnion bearings on high temperature mixers. Particular applications have involved operating temperatures of from 300-350 F continuously with bearings ranging from 4 to 6 in. in diameter at speeds of approximately 50 rpm.

On the basis of our performance tests and considerable operating experience, it is believed that the greases which perform most effectively in the laboratory screening tests can also be expected to give better than average performance in the field. To date, in every instance, those greases which have appeared to be inferior on the basis of the indicated laboratory procedures have been found unsatisfactory in the field. The reliability and value of the procedure discussed herein have been confirmed by the fact that in the widespread company operations, 80 per cent of the grease lubricated bearings are being lubricated to advantage with grease of a single consistency. Furthermore, the choice is not limited to a single type of grease with reference to composition, and several different sources of supply are available for suitable so-called multi-purpose greases.

CONCLUSION

A method of laboratory screening of greases intended for application as multi-purpose greases has been outlined and briefly discussed. This procedure is further subject to performance testing under a wide variety of practical conditions with competent engineering supervision. Experience to date covering a period of three years indicates that the laboratory performance tests in question are of real value in selecting greases with a better than average probability of providing satisfactory operation in production. It is suggested that reliance upon laboratory bench tests of the type indicated, as a prelude to performance testing, is a more satisfactory procedure than that of relying upon either method alone.

BIBLIOGRAPHY

1. ASTM Standards on Petroleum Products and Lubricants, D217-48.
2. Institute Spokesman, Vol. VI, No. 12, March, 1943.
3. ASTM Standards on Petroleum Products and Lubricants, D566-42.
4. National Defense Research Committee Methods C-75T, C-77T; AN-G-3A Specification.
5. Coordinating Research Council Report, Project CLIG-25-43, May, 1945.
6. Specification 14-L-5, Bureau of Ships Navy Specification.
7. ASTM Standards on Petroleum Products and Lubricants, D942-47T.
8. National Defense Research Committee Method C-75T, AN-G-5A Specification.

DISCUSSION

PRESENTED BY

N. I. WHITELEY, Lubrication Engineer, American Steel & Wire Co., Cleveland, Ohio.

W. M. SCHUCK, Lubrication Engineer, Armco Steel Corp., Middletown, Ohio.

A. CICHELLI, Lubricating Engineer, Bethlehem Steel Co., Sparrows Point, Md.

C. A. ZEILER, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

E. M. KIPP, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

WARD HOLLAND, Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio.

C. T. LEWIS, Lubrication Engineer, Republic Steel Corp., Warren, Ohio.

W. P. PRIESER, Purchasing Department, Aluminum Co. of America.

W. H. MANDY, Lubrication Engineer, The Texas Co., Coraopolis, Pa.

N. I. Whiteley: You are faced with the fact that the purchasing department does the buying. It seems to me if you are going to spend three times as much for a lubricant to perform the same functions as your present lubricants, and those lubricants have been doing what you consider at least a good job for a number of years with no trouble, you had best have complete data to present to your purchasing department and the people in your mill. Some of these tests made by Dr. Kipp and Mr. Zeiler, of many lubricants now on the market, show a savings of from one-third to one-half in consumption. If this could be proven in actual operation in the mill, it would certainly justify the extra expense.

W. M. Schuck: It is my opinion that the pioneering work being done by these gentlemen toward establishing a finished method of evaluating grease lubricants through the medium of laboratory bench tests is a most valuable contribution to the art of lubrication engineering. Naturally, any untried, new procedure will possess difficulties that require the trial of many methods before a final authoritative practice can be established. The practice that you have just heard explained is inclusive and simple, yet it arrives at a fairly conclusive and accurate evaluation of an unknown grease product.

There are, however, several questions concerning this laboratory series of tests that further explanation may help in understanding. First, is there a need for both the motorized grease worker test and the Shell roller test? You state that the roller test is more severe and, with that evidence in mind, is the less drastic worker test an absolute necessity?

Second, is there any attempt to deliberately add water as a contaminant to either of these tests to simulate some extreme mill conditions?

Third, are all of the tests given the same evaluation importance in arriving at the final result or are some tests more important than others?

Fourth, what is the amount of laboratory time required to completely evaluate a new product? Finally, do you believe that an apparent viscosity graph covering

the expected operating temperatures would further aid in evaluating a new product, particularly where centralized grease systems are to be considered in the plant applications?

A. Cichelli: This paper is quite thought-provoking. Dr. Kipp has demonstrated to my satisfaction that it pays to spend a little money on grease testing equipment. Heretofore, when specific performance data was sought, the vendor was approached for such information, and more often than not, he was quite willing to supply it if he happened to have the apparatus available. However, correlation of data from separate laboratories and different instruments is not trustworthy.

What the steel people need is a program like Dr. Kipp's and Mr. Zeiler's. It is quite possible thereby for a consumer to determine beforehand for himself how various products might be expected to perform in the field. Such a screening process is of great value to a plant lubrication engineer and could result in saving large amounts of time and money.

I wish to offer a comment on multi-purpose greases. Recognizing the advantages to be gained in reducing the number of inventory items by the application of these greases, I wonder, if in the overall picture, this definite gain is not offset by several disadvantages. The person who is not only responsible for reducing maintenance costs, but also holding the plant lubrication costs in line, is faced with a real challenge to find the most economical product while at the same time rendering a maximum return in reduced maintenance. A move towards the substitution of multi-purpose greases reduces the number of inventory items to be carried and in some cases results in less grease consumption. However, in steel plants, where one speaks in terms of hundreds of grease drums per month, the cost factor becomes very prominent indeed and the higher prices of multi-purpose greases must be justified.

Bear in mind that many steel plant applications, such as strip mill bearings, require excessive amounts of grease to be used to keep out contamination. I venture to say that most of the grease used in these applications serves in the capacity of a seal rather than a lubricant. Therefore, in such instances the higher priced multi-purpose greases would be wasted in the same manner as the conventional greases and would be a costly application.

I should like the authors, if they would, to draw from their experience and tell us if they have any information showing the trend of maintenance and lubricant costs comparing them with those in effect before they converted 80 per cent of the applications to the multi-purpose type grease. In other words, does the combined lubricant and maintenance cost drop sufficiently to offset the higher cost of the multi-purpose grease?

C. A. Zeiler: I am afraid I cannot tell you too much about costs. The laboratory does not enter into the cost part of the project. The grease test data are referred to the purchasing department and to the liaison group, and their job is to establish over-all performance, including costs. As the application becomes more severe, you need better greases. The cost of special-purpose greases is rising. There is no doubt about that. The high speed and high temperature applications call for greases used only for one purpose.

Now the cost of multi-purpose greases has come down. When we first started the program, we used two all-purpose greases of really outstanding specifications. They worked out fine. Both greases happened to be barium base grease, and presumably that is why there was a rumor that we favored barium base greases. We have no preferences relative to composition.

A surprising number of multi-purpose greases have come in for testing purposes in the last few years. Now the reduction in first cost has been marked in the multi-purpose field, and I think your purchasing departments will agree that the trend is downward on the cost of multi-purpose greases and is going upward on orthodox and special type purpose greases, so eventually the cost problem of putting all-purpose greases in the plant will become much simpler than in the past. We are using these greases now which shows that the plants believe their use economical.

E. M. Kipp: We feel that we obtain additional information by using both the grease worker test and Shell roller test. We have not deliberately added water in these tests but think this is a good idea. For general purpose applications, all tests are given same rating, but for specific applications some tests may be weighted. It takes about two man-days to completely evaluate a new product. An apparent viscosity graph covering expected operating temperatures would aid in evaluating a new product.

Ward Holland: The screening test program covered in Dr. Kipp's paper is believed to be well founded, based on past field experiences. It is hoped that sufficient correlation will be offered thereby to offset the many variables encountered with existing testing programs.

Adoption of the tests covered may not give the exact answers with relation to all field conditions encountered, however the results obtained therefrom can be used as a yardstick for general plant evaluations. If this immediate group of tests, or any others which might be introduced in the near future, can be accepted as a standard procedure by both the supplier and consumer of lubricants, it will undoubtedly prove to be a milestone in the field of lubrication. One of the most serious complaints offered by the consumer regarding past testing procedures is that of the various suppliers modifying so called standard tests with the introduction thereby of a completely different end result from that found with no modification of the standard test. I do not mean to infer by this that modifications are not beneficial, but rather that correlation of the results obtained is believed to be of little value unless the same test procedure is followed by all parties concerned. Any deviation from the standards should be developed on the basis of simulating field conditions wherever possible. In this manner, the confusion surrounding misinterpretation of results presented by the various individuals can be held to an acceptable minimum.

We, in our organization, recognize the value of instituting screening tests and at the present time are in the process of establishing a program of this type. Special emphasis has been placed upon simulation of field conditions in order that more definite conclusions can be established with respect to the many and varied operating conditions. In some cases the lubricant is actually employed as a medium for purging the bearings

of contaminants which have found their way into the bearing housing. This practice has been followed in several older operations where inadequate sealing has been provided. It is felt that in such cases the so-called multi-purpose greases would not prove to be economically feasible to use. Where proper sealing has been incorporated in the machine design it is felt that multi-purpose greases can truly offer the value intended by virtue of extending the service life of the lubricant for a period sufficient to offset the cost increase surrounding their usage. Simplification of the field applications can be enhanced materially by their adoption. Considerable thought should be given wherever study indicates an effective savings and elimination of misapplication can be offered by employment of the multi-purpose greases for general use.

Any test procedure which will assist in arriving at a more complete evaluation of multi-purpose greases will be most welcome in our search for better lubrication in the most economical manner.

C. T. Lewis: I wish to raise the question as to whether or not it would be advisable for most laboratory testing, to restrict the ten listed tests to probably five? My view there being based primarily on the assumption that the grease supplier, should be reliable enough to make it possible to eliminate the reading and evaluation of the bleeding and evaporation tests.

For a multi-purpose grease, I believe the first requisite test should be a dropping point test. If the dropping point is too low, it automatically eliminates the specific grease from use and consequently from the need for further tests.

For the second test, I question whether or not the Shell four-ball test should not be used to eliminate any grease that might not be able to carry the loads required of it.

Most bearings in use, of course, have considerable air space, and this brings in the Norma-Hoffman oxygen test. This should be questioned before the durability and water resistant tests. The water leaching test is equivalent to a field test, wherein you have water entering through a faulty seal, and merits the position of the fourth test.

For the fifth and final test it is believed that it would be satisfactory to run a wheel bearing test, as you would in this test, probably obtain all the temperature you would encounter in applications and you would also obtain air breakdown, the breakdown or loss of plasticizer, and whatever other effects that might be expected to take place in use.

C. A. Zeiler: Mr. Lewis said something about restricting the number of tests to five. We may do that eventually; however, we are not too certain in our minds as to just what five we would restrict them to.

I think the idea of using as many tests as we could, of course, was to get a possibly more favorable over-all rating. If a grease falls down badly on one test, it still has a chance to recover and get a favorable rating by passing the others. I might say, however, that we have certain limits in the specifications for each of the several tests that a grease must pass.

As a research laboratory, we have carried through every grease that has been subjected to us for tests. We run a dropping point test first. If we find the grease does not comply, it would, of course, fail the specifications right then and there. But we still run the remaining tests as a matter of information. We do run all the tests on any sample submitted.

W. P. Prieser: I am prepared only to describe a situation which we have found in our own organization. Perhaps it is unique in itself, and you people in the steel industry will not benefit by it.

We did introduce multi-purpose greases very extensively into our plants. Taking a good sized plant as an example this material displaced fourteen other brands of grease. As you would expect from the law of probability when fourteen items are displaced with one, they are not all of a higher or all of a lower cost. As a matter of fact, most plants were using greases costing up to $0.35 a pound.

In our own picture, in almost every case, the total cost of the grease was reduced by changing to one general-purpose lubricant. Admittedly this type is not the cheapest material on the market, but in our own situation the over-all cost of grease was reduced.

W. H. Mandy: I have a question regarding the two tests conducted to evaluate penetration changes — the motorized grease worker at 10,000 strokes and the Shell roller test. Did you find any benefit of one test over the other or were the two tests selected because one simulated operating conditions of a plain bearing while the other simulated conditions of a roller bearing?

I also have another question. I believe you stated that in addition to the ten tests described you conducted other tests. I presume the other tests were designed to simulate actual operating conditions found in your plants. Have you been able to devise tests more nearly simulating these conditions than the established ASTM tests? For instance, the demulsibility tests for circulating oils seem to be of little value except to indicate the degree of refinement of the oil. The prescribed methods of test do not simulate mill operating conditions sufficiently to enable us to predict the performance of an oil. Two oils with the same demulsibility number do not necessarily perform the same in a circulating system.

The bearing manufacturers who include the demulsibility test in their specifications would like something better to indicate the water separating ability, but no one has come up with anything better along this line. Perhaps you have some test that more nearly simulates actual operating conditions.

C. A. Zeiler: I might say, in regard to plain penetration and roller penetration tests, we do not take into account whether the grease to be used is for plain or roller bearings.

As for getting the tests adopted by others, most of the tests described are ASTM tests or tests under development by other bodies such as the NLGI, CRC, and Federal agencies, with one or two exceptions such as the high temperature grease beater. I do not know of anybody else running the Navy high temperature beater test the same way we are. The reason we run the tests the way we do is because we have applications in our plants where high temperatures are important, and we want to know how the consistency of the grease is effected by the high temperatures. We run this test at temperatures of 300 to 320 F.

EXTREME PRESSURE LUBRICANTS

By JAMES H. LEWIS
General Foreman, Maintenance Mechanical
United States Steel Co.
Clairton, Pa.

. . . . extreme pressure lubricants, properly applied, satisfy a real need . . . .

▲ BEFORE the introduction of the hypoid drive by the automotive industry, all gears, worm drives, pinions, speed reduction units and similar moving parts were lubricated by non-compounded mineral oils, of various viscosities including the heavier valve oils and greases which seemed to be satisfactory. However, the development of the hypoid gear drive, and the extremely high pressures involved in its operation, caused the automotive industry to seek a lubricant that would withstand such extreme pressures and reduce the welding and excessive wear which were prevalent with the use of the petroleum products then available for such applications.

This problem was solved by the petroleum industry by the development of what were known as "extreme pressure gear oils." The use of these lubricants has gradually been extended to all types of equipment in which high pressures are encountered between moving parts. Today, nearly every major supplier of lubricants can furnish an "extreme pressure lubricant" for most any application that may be encountered in industry.

The first question that may enter the minds of persons responsible for lubrication of industrial equipment is: Where should an extreme pressure lubricant be employed and how can it be determined that such a lubricant is necessary?

The first part of the question has no definite answer in that extreme pressure lubricants should be employed where the high film strength of such lubricants is needed to prevent excessive wear to the parts being lubricated. The second part of the question can only be answered by observation of the units under operating conditions. Even then it is questionable whether a true picture can be obtained before damage occurs due to overloading, misalignment, or other causes which cannot be immediately corrected. It is generally accepted, however, that extreme pressures will be encountered in all types of geared drives, particularly in steel mill and similar applications, and will cause damage to such units unless extreme pressure lubricants are used. This is particularly true during the running in period in which component parts are not perfectly matched to each other. For this reason it is recommended that all gear boxes, pinion drives, worm gear units, and the like be lubricated with an extreme pressure lubricant as an added factor of safety or insurance against damage.

It must be realized, however, that the use of extreme pressure oils on all geared drives will not, in all cases, conform to the recommendations of gear manufacturers. This is especially true on high speed units. The reluctance of some manufacturers to approve the use of this type of lubricant can be readily understood when it is realized that there are several types of extreme pressure lubricants, some of which cannot be used interchangeably. Some of the extreme pressure compounds cannot be used where there is moisture present because of chemical instability.

In spite of the reluctance of some manufacturers to recommend extreme pressure lubricants, for fear of misapplication, the selection and use of such lubricants by a competent lubrication engineer who understands the limitations of the various types, will result in safer operation, and reduced repair and maintenance costs. Training and experience in the technical phases of lubrication are of increasing importance to industry. The application of modern lubricants cannot be safely delegated to the mechanic or the average maintenance foreman if good results and savings are to be realized.

It is interesting to note that when an extreme pressure lubricant is applied to a unit when it is not recommended by the manufacturer, the lubrication engineer will be held responsible for any failure, no matter what type of lubricant is used or what the actual cause of failure might be. The lubricant is usually the first thing to be questioned when a unit or its lubrication system fails. Therefore, the lubrication engineer must be constantly aware of all conditions that might cause such failure in order to properly defend his judgment in selecting and applying the particular lubricant used.

An interesting example of what can happen when an extreme pressure lubricant was used, contrary to the manufacturers recommendations, occurred on a new installation at one of our plants several months ago. The unit involved was a motor driven speed reducer used for transmitting power on a large production unit. It was operating in the open and subject to all climatic conditions.

The bearings of the geared speed reducer were split type, made of one of the standard lead bronze alloys and splash lubricated. The manufacturer recommended a cylinder oil of 210 SSU at 210 F for summer use and a mineral oil of 100 SSU at 210 F for winter use.

Because of the inconvenience of having to change oil with the seasons, and because the operation was such

that the equipment would stand idle from several hours to several days in cold weather, the writer insisted that an extreme pressure gear oil of the lead naphthenate type be used as an all-year lubricant. The recommended lubricant had a pour point well below zero, which was safe enough in cold weather.

The first day the equipment was tested, the gear reduction unit heated up alarmingly. The erector stopped the test and called in a representative of the manufacturer. During the discussion held to determine possible reasons for the trouble, the manufacturer's representative pounced upon the use of the extreme pressure gear oil as the possible cause of the overheating. His objection seemed to be that all such lubricants tend to corrode metals in contact with it thereby causing increased friction, excessive wear and overheating.

The unit was finally dismantled, and the oil grooves in the bearings were found to be filled with lead. The manufacturer's representative at once jumped to the conclusion that the lead naphthenate type of gear oil had deposited the lead in the bearings and caused the trouble.

This notion was quickly dispelled when upon examination the bearings were found to have been cast in such a manner that the lead in the copper, tin, lead alloy had not alloyed itself properly with the copper and tin, but had become stratified throughout the casting. Also, the bearing had not been scraped to fit the journal properly, and all of the bearing pressure had been exerted on a few high spots which resulted in the bearings being heated hot enough to melt some of the stratified lead on the bearing surface which then flowed into the oil grooves.

The bearings were then scraped and fitted properly to the journals, and the unit was reassembled. It has been operating since then with the same extreme pressure lubricant as originally applied.

The selection of the types of extreme pressure lubricants to be used generally within a given plant or plant area should be made cautiously. Due consideration must be given to the operating conditions, method of applying lubricant, atmospheric conditions, and the like. The selection must be made so as to obtain a compound compatible with these conditions.

For example, in applications where there is a chance for moisture to be present either from excessive condensation within the lubricated or storage portions of the equipment or from other sources, the lead-sulphur type of lubricant would be chosen. If no chance of moisture contamination is found, the chlorinated sulphur types might be acceptable and cheaper.

Inspection and testing schedules on units in which extreme pressure gear oils are used should be set up in all cases. The schedule will vary somewhat depending upon the type of unit, the lubrication system used, and other surrounding conditions. (Experience indicates that units which are self contained and are under constant operation require a great deal of attention. Such units require little or no makeup due to leakage. Units which operate intermittently or are lubricated by large lubricating systems require less attention). This is true largely because of the deterioration of the extreme pressure qualities of the lubricants under constant use. This point will be discussed more fully later in the paper.

In all cases it is preferred to have a complete analysis made on the lubricant before it is charged into the unit. This data will afford a means of checking the analysis of periodic samples against the original lubricant. Frequent analysis of samples taken from the unit will indicate the condition of the lubricant, and from this information a schedule for inspecting and testing the units may be set up.

The following analysis should be sufficient to enable a determination of the condition of the units in service:

1. *SSU viscosity* — Any pronounced increase in viscosity denotes that sludging is probably taking place. The temperature at which the viscosity test is made should be the same in all tests.
2. *Load carrying ability* — The same test method must be employed on all samples as was employed on the original samples if the tests are to be comparable. If the load carrying ability of the used samples is lower to any marked degree than that of the original sample, it is an indication that the extreme pressure agents of the lubricant are being depleted due to continued operation. Further analysis should be made.
3. *Sulphur* — When the load carrying ability is found to be lowered in the used sample, the sulphur content should be checked to determine whether it is less than that in the original sample.
4. *Chlorine* — If chlorine was present in the original sample, it should be checked the same as the sulphur.
5. *Lead* — If lead was present in the original sample, it should be checked the same as the sulphur and chlorine.
6. *Neutralization number* — If an increase in viscosity is noted in the used sample, a check on the neutralization number should be made in order to determine the possibility of sludging.

In the event that a petroleum testing laboratory is not available, it is likely that the supplier of the lubricant will be able to assist in getting the information required in order to set up and maintain a good inspection and testing schedule for the units or systems in service.

Extreme pressure lubricants are made by compounding certain chemical elements with a good grade of mineral oil of the desired viscosity as a base. The additives, known as extreme pressure agents, are generally sulphur, chlorine, phosphorous and lead in the form of lead naphthenate or lead oleate. These agents are used singly or in various combinations to obtain the required load carrying ability in the compound. Regardless of the type of agent used or the method used in making the compound, the function of the extreme pressure agents in the oil are identical.

The function of the extreme pressure agents used in extreme pressure lubricants is to combine with the metal of the mating parts being lubricated to form a metallic protective film on these parts which will be strong enough to prevent welding or seizure of the metals in contact. This protective film has been found to be in the form of a metallic oxide of the agent used and the metal.

Several theories have been advanced to explain how the protective film is formed. One is that the agent in the oil first penetrates the metal parts forming a coating

of monomolecular thickness with the metal. Due to high pressures, momentary metal to metal contact occurs, creating high temperatures which activate the agent in such a manner as to cause a chemical combination between the agent and the metal in the form of a thin oxide film. This film prevents seizure or welding of the metal parts in contact.

Regardless of how or when the activation takes place, it is logical to believe that when the agent is under continual activation, it will be dissipated and the load carrying ability of the lubricant will be reduced to a point where it will no longer be able to withstand the pressures encountered.

On several occasions, the writer has encountered conditions of metal seizure, welding, and actual metal working on partially rebuilt units lubricated with extreme pressure oil when the same unit had operated satisfactorily with the same lubricant under the same loading conditions before it was rebuilt or old parts replaced with new ones. These conditions were caused by the improper mating of the new parts and resulted in excessive high pressure and temperature which depleted the extreme pressure agents in the oil.

The most outstanding case of this kind occurred on a set of pinions on a reversing blooming mill. A pinion was broken in the set and the complete set was replaced with a new set of pinions. The unit was charged with an extreme pressure lubricant which carried a 51-lb load on the Timken machine. After 72 hours of continuous operation, the pinion teeth had worn to a point where gouging had taken place at the base of the teeth.

The lubricant was checked and found to now carry a load of only 25 lb on the Timken machine, with a score of 33 lb. Further analysis of the sample showed a drop of 0.2 per cent in total sulphur and 0.5 per cent in total lead. The lubricant was no longer an extreme pressure lubricant.

A second set of new pinions were put in service with a new charge of the same lubricant which was tested and found to carry the same Timken load as the previous charge. These pinions were examined each day and no evidence was found of any unusual wear. The lubricant was checked daily and found to carry a 43-lb Timken load with a drop in lead and sulphur in the hundredths of a per cent.

After some weeks of operation the first set of pinions, which had been dressed, were put back in service with the same lubricant that had been used to lubricate the second set. The pinions were examined daily and the mating surfaces were found to be improving, however, after one week the lubricant had dropped to 25-lb Timken load.

Working on the theory that this set of pinions were improperly machined and improperly mated, it was decided to replenish the supply of extreme pressure agent and continue to run them. This was done by adding lead concentrate to raise the Timken load reading to 51 lb. Several additions were made during the ensuing several weeks to keep the extreme pressure agent replenished. These pinions have now been operating over a year. The teeth have worn evenly and smooth, and the lubricant is now carrying a 43-lb Timken load with no additions of concentrate.

This case seems to prove the contention that where extreme pressure conditions prevail due to mismating of parts, misalignment, or other causes, the extreme pressure agents are activated and rapidly depleted in the formation of protective films until the parts wear into more early perfect alignment. As this condition is approached the dissipation of extreme pressure agents decreases to practically zero.

The fact that extreme pressure agents are depleted under adverse conditions does not prove that extreme pressure lubricants are unstable as is often contended.

There is some difference in the action of different extreme pressure oils when they are tested for load carrying ability on testing machines. These differences seem to be related to the different pressures and temperatures necessary to cause the so-called activation of the extreme pressure agent. Some types of gear oils will carry the specification load on the first test run, while others seem to require conditioning at lower loads before the higher specification load is applied. This peculiarity is observed frequently in running tests on the Timken machine.

This characteristic does not seem to affect the protection given to operating units by the oils. It is believed that when such oils are put in service, the conditioning is accomplished automatically by the working of the oil in the unit being lubricated.

EXTREME PRESSURE GREASES

The excellent characteristics obtained by using extreme pressure agents in lubricating oils have been incorporated in the manufacture of greases. Surprisingly, the cost of this type of grease is not as prohibitive as it was several years ago. Competition and extended applications are given credit for the present lower cost of this type of lubricant.

The principal applications for extreme pressure greases in industry are the lubrication of antifriction and sleeve bearings. There has been some controversy as to whether it is advisable to use a grease of this type as a general purpose grease.

Several users have reported corrosion on bearings and journals after using some of the extreme pressure greases. The corrosion has been attributed to the extreme pressure agent employed combining with water which was present or entered the bearing in some way.

As stated previously in the discussion of this condition in gear oils, some additives do react with water more readily than others, and where moisture conditions exist, care must be used in selecting the proper lubricant.

EXTREME PRESSURE GEARSHIELD

A discussion of extreme pressure lubricants would not be complete without some mention of extreme pressure gearshield for use on open gears. The first products of this type developed were common soap greases with extreme pressure agents added.

This development was some improvement over the gearshields then available, but did not have the necessary characteristic of clinging tightly to gears — adhesiveness. Several years ago a product was introduced by a large manufacturer of extreme pressure lubricants which incorporated this important characteristic.

The product was an extreme pressure lubricant with excellent adhesiveness which could be applied by spraying it on open gears. The qualities of this product were quickly duplicated by other companies so that today this type of lubricant is available at a cost which is attractive when the results are compared with those of ordinary gearshields.

The sprayability of these products is produced by the addition of a diluent or solvent which maintains the lubricant in liquid form until it is sprayed on. Upon application the solvent evaporates leaving a smooth even film of lubricant on the gear teeth or other parts sprayed. Two definite advantages are thus obtained by the use of this type of lubricant.

1. *Method of application* — The spray method of application is much safer and much quicker than application by swab or brush.
2. *Consumption* — Fewer applications of sprayed gearshield are required than nonsprayed gearshield because of the more even and better distributed film. The spray method results in less loss in application. Consumption has been reduced as much as 85 per cent in one mill and 79 per cent in another after adoption of spray application.

The combined savings in consumption of lubricants plus savings in repair and maintenance costs on open gear drives have been very gratifying to the management of many plants.

In conclusion it would be in order to stress again two important factors in regard to extreme pressure lubricants:

1. The selection of the type of extreme pressure lubricants to use in any given application should not be made until all factors effecting such lubricants have been studied and evaluated.
2. Extreme pressure lubricants are desirable where occasional overloading is expected, and necessary where continued loading or operating conditions show evidence of excessive wear on moving parts.

DISCUSSION

PRESENTED BY

CHARLES TAYLOR, Lubrication Engineer, Sun Oil Co., Pittsburgh, Pa.

JOSEPH A. RIGBY, Manager of Engineering and Sales, The Brooks Oil Co., Pittsburgh, Pa.

ANTHONY J. ZINO, JR., Swan Finch Oil Corp., New York, N. Y.

GEORGE DAVIS, Lubrication Engineer, Shell Oil Co., Pittsburgh, Pa.

Charles Taylor: I would like to say that when these additives are added to oil, you sometimes get different reactions than you anticipate; therefore, the study of additives to oil, as far as the oil companies are concerned, is still one of their principal objectives. The object is to know more about the way lubricants react when in actual service.

The stability of this type of lubricant, a lead lubricant in oil, naturally is something that we are all working on. The regular testing for film strength forms a very important study, and I think that as more case histories, such as Mr. Lewis gave, on that particular subject are studied, we will find better lubricants.

Joseph A. Rigby: While this type of lubricant is not new, the actual time period of application will not exceed more than the last twenty years and due credit must be acknowledged to the automotive industry as a leader, not only in mechanical or engineering development, but also in demand to the petroleum industry for improved lubricants. Industry in general had been slow, and to some degree negligent, in deviating from the beaten path in the use of what was considered good enough in lubricants available.

A few years back, mechanical equipment was thought to require periodic replacements of the bearings, gears, slides and other parts from what was believed to be normal wear. This condition was accepted on the basis of what was considered adequate lubrication with the best quality lubricants available. Naturally maintenance costs were high, and the availability of the equipment was a low factor. Improvements were made, in design of equipment, alloy and heat treated materials, enclosure of parts subject to wear and scientific application of lubricants. With these aids, some improvement was made but there remained a problem to be solved in advancement of lubricant performance which is believed can now be credited to the development of extreme pressure lubricants which usually also offers other inherent advantages. It can now be said "that bearings, gears, and other parts need not wear out."

Extreme pressure lubricants have usually been eagerly accepted by those with maintenance responsibility but designers and manufacturers have been reluctant to make recommendations, grant approval, or even display earnest effort to deviate from straight mineral oils or mild compounds for some increase in film strength. Mr. Lewis is to be commended in citing an example which may be considered a prejudiced viewpoint, but one which is timely to the subject. This situation is improving, however, it has been necessary to have such experience in examples to combat the situation in advancement of extreme pressure lubricants.

Time does not permit this discussion to cover the extensive discourse it is possible to develop on the subject; however, a salient characteristic may be offered in further support of extreme pressure values. This is, that over a wide range of viscosities, the film strength of extreme pressure lubricants can be and is maintained constant. This characteristic is one of paramount importance in substitution of viscosities which are at least half or 50 per cent less than other lubricants of straight mineral oil or others of mild compound nature. This practice has been in vogue for so many years that proof prevails of practical acceptance and positive advantages. Advantages are: decreased fluid friction which results in lower operating temperature, decreased power demand, better flow to all parts requiring lubrication, lower pour points for cold weather service, improvement of precipitation control, and more rapid separation of moisture. The latter points simplify purification processing and guarantee more efficient filtering of contamination from the lubricant.

Mr. Lewis has developed an important section in the

paper of variance or change in Timken machine film strength of lubricants under adverse conditions. It can be recognized that some physical change could be made to a lubricant in sludging by oxidation, increase of viscosity, change of color and possibly other factors. But the film strength should remain constant if the lubricant was one compounded for stability in film strength. Stability is positively essential and can be accomplished.

The subject of open gear lubrication is of deep interest in eliminating the necessity to heat lubricants for application, but particularly in the emphasis on spraying. Not enough stress has been made for this logical method of application while gears are in motion. In addition, the inherently thin film of solvent type open gear lubricants decreases power drag to a negligible factor thus actually producing extensive power savings. This is particularly exemplified in cold weather service and eliminates the overload in starting which is a serious condition under exposure to low temperature operations.

The description of film deposit on wearing surfaces is one of the outstanding features presented in this paper. There are some authorities who have discussed this action and advantages, but little has been published to combat the skeptical attitude which is known to exist. Mr. Lewis has advanced a point for which hope is expressed that scientific study and research will bring this subject to a more prominent position in the educational information that users of extreme pressure lubricants would be eager to acquire.

Anthony J. Zino, Jr.: After listening to Mr. Lewis' very interesting and enlightening paper on extreme pressure lubricants it is apparent that the steel industry today is being plagued with the same problems in gear lubrication that faced the automotive industry in early '30s, viz., the problem of gear lubricant standardization. You well recall that during this period, the automotive industry introduced the hypoid gear rear axle unit on a fairly large scale, and, of course, not to mention its subsequent lubrication problems. You will also recall, how you were cautioned when you purchased your new car "not to mix brands and be sure and change religiously every six months."

The entire oil and automotive industry was in more or less a state of confusion for several years. Finally, a very definite set of labratory and field tests were established by the various automotive firms whereby lubricants passing them would be approved for use in their hypoid drives. Eventually, as we have all seen, a coordinated program was established between the oil and automotive industry whereby approved lubricants of one firm today can be safely added to those of another without the former problems of compatibility, etc.

Unfortunately, such a state of harmony and bliss does not seem to exist in industry in general. Various engineering societies and associations have tried from time to time to unravel this chaotic situation. Gear manufacturers, I believe, recognize the problem but apparently, with a few exceptions, will neither approve the general use of so-called EP gear oils in their equipment nor test them in their laboratories. Their reluctance is unquestionably due to the corrosive nature of some products, and the general lack of compatibility of most products. The proper definition and classification of extreme pressure gear lubricants would in time help to remove this barrier.

There is no question but that a definite need exists for extreme pressure gear lubricants in the steel industry. However, before the lubrication engineer can perform his job efficiently, the problems of compatibility, foaming, corrosion and oil-thickening which have been reduced to a minimum in approved automotive gear lubricants—and which are still plaguing the steel industry—must be ironed out. Many of the extreme pressure additives formerly ruled out of automotive gear lubricants are still being used in this industry. Is it any wonder that two differently branded EP gear oils cannot be mixed without subsequent trouble?

Regarding the general use of EP treated oils and greases within a steel mill, experience has proven that there are many benefits to be derived from them—whether approved by the equipment builder or not:

1. *Increase factor of safety*—The thin, adherent, anti-weld films, which result from the use of EP oils, are present on all working surfaces at all times and provide gear and bearing protection when needed.
2. *Longer equipment life assured*—In view of the heavy duty operation of steel mill equipment and operators general attitude toward it, EP lubricants are added insurance for longer equipment life.
3. Resultant economies far over-balance their initial costs.

George Davis: I agree with the author that extreme pressure lubricants are absolutely necessary where conditions of boundary lubrication prevail or where this condition is apt to occur. I wonder, however, if the recommendation for EP lubricants for worm gears is the best that we can obtain. Where large areas of contact prevail, oiliness is more important than EP characteristics and, therefore, the so-called oiliness additives are of much more value. I believe that the usual recommendation of a compounded steam cylinder oil has been entirely satisfactory for worm gears.

Mr. Lewis' statement that a plant lubricant engineer has to be constantly aware of all the conditions that might cause failure cannot be commended too highly. Many times products such as EP lubricants are thrown out, purely because of mechanical trouble and not because of fault in the lubricant. If the engineer in charge of lubrication is aware of all the conditions that can cause a failure and take steps to correct them, many times the oil will be proven emminently satisfactory instead of being rejected.

The author's statement that a chlorinated sulphur type EP lubricant should not be used where moisture is present should be more specific as there are a number of these active type lubricants on the market today that are not corrosive and have been in use for a number of years.

I heartily agree with Mr. Lewis' basic premise that EP lubricants, properly applied, satisfy a very real need. This is particularly true today when the mills are operating on a high production schedule of war demand for steel.

WHAT TO LOOK FOR IN HYDRAULIC FLUIDS

By ANTHONY J. ZINO, JR.
Swan-Finch Oil Corp.
New York, N. Y.

. . . . hydraulic fluids must have stability, proper viscosity characteristics, demulsibility and lubricating value, and must prevent rust and corrosion . . . .

▲ I do not believe that there is a subject in the field of lubrication today which creates more interest and discussion than hydraulics and the application of petroleum oils as hydraulic fluids. The reason for this interest is due to the radical change which is slowly taking place in machine design. Hydraulic drives are being utilized wherever practical and economically feasible. The value of hydraulics in machine and equipment design is apparent when you realize the inherent advantages that hydraulics offer over mechanical and electrical methods. Simplicity and flexibility of operation; elimination of cumbersome gearing; and, smoothness of operation.

Our subject is in the application of petroleum oils as hydraulic fluids in industrial equipment. Those of you who are familiar with this industry realize the fact that the machine tool and metal-working industry absorbs a tremendous amount of the hydraulic equipment output of this country. It is in this industry that the greatest amount of research and development work is being carried on. We find there the simplest of circuits to the most complicated circuit.

Let us take a look at a few changes in machine tools. As the successful operation of a hydraulically operated machine is dependent upon the fluid used, what are the chemical and physical properties of petroleum oils that play an important part to their application in hydraulic circuits? How important are these characteristics?

The primary function of the hydraulic fluid, as you know, is to transmit power and eliminate the usual cumbersome mechanical gearing formerly required to do the same operation. However, in addition to transmitting power, a hydraulic fluid has other important functions to perform, viz, act as a sealant and also as a lubricant. As a sealant and as a lubricant it must possess certain specific properties. The analysis of those physical properties essential to oils when used as hydraulic fluids and the role they play in hydraulic operation is the theme of this paper.

Let us first consider specifications. See Table I and II.

Figure 1 — Nomograph gives pressure drop per ft of tubing for turbulent flow only.

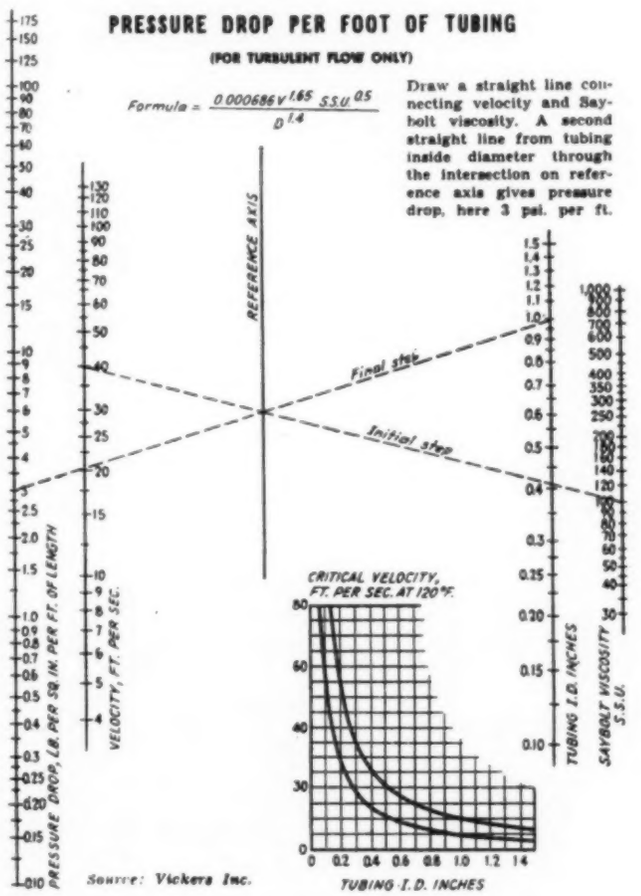

PRESSURE DROP PER FOOT OF TUBING
(FOR TURBULENT FLOW ONLY)
Formula = 0.000686 V^1.65 S.S.U.^0.05 / D^1.4
Draw a straight line connecting velocity and Saybolt viscosity. A second straight line from tubing inside diameter through the intersection on reference axis gives pressure drop, here 3 psi. per ft.
REFERENCE AXIS
Final step
Initial step
PRESSURE DROP, LB. PER SQ. IN. PER FT. OF LENGTH
VELOCITY, FT. PER SEC.
CRITICAL VELOCITY, FT. PER SEC. AT 120°F.
TUBING I.D. INCHES
SAYBOLT VISCOSITY S.S.U.
TUBING I.D. INCHES
Source: Vickers Inc.

TABLE I
USUAL SPECIFICATIONS

1. Gravity, A.P.I.
2. Viscosity, S.U.S.
3. Viscosity index.
4. Flash point, F.
5. Fire point, F.
6. Neutralization number.
7. Carbon residue.
8. Color, A.P.I.
9. Pour point, F.

TABLE II

SERVICE PROPERTIES

1. Viscosity.
2. Viscosity index.
3. Demulsibility.
4. Oxidation stability.
5. Lubricating value.
6. Rust and corrosion preventive qualities.

Current hydraulic oil specifications, as written by both the hydraulic engineer and the oil supplier, are the usual petroleum oil physical properties as indicated in Table I. Although these "specs" and tests so serve a useful purpose—primarily in obtaining uniformity of product and consistent results; of greater interest, however, are those physical properties which have a more direct bearing on the successful operation of a hydraulic circuit, viz, their service performance characteristics or service properties, Table II.

Gravity API—Of no direct value in hydraulics. No longer denotes quality, method of refining, or source of crude. Useful only in the computation of the oils absolute viscosity and specific gravity.

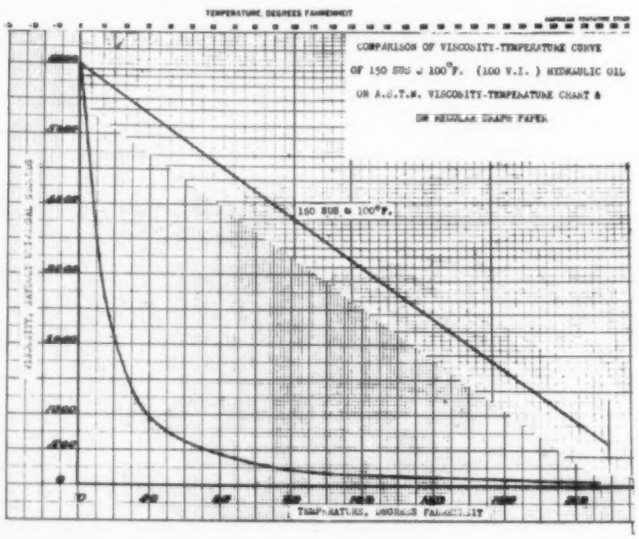
Flash and fire points — Degrees F — Of no direct value in hydraulics. More value to the refiner in controlling his process. Operating temperatures rarely approach these values. However, "hotspots" can exist in a circuit wherein temperature would exceed the oil's flash and fire points.

Neutralization number — The neutralization number of an oil as defined, is the number of mg of KOH required to neutralize the acids in one gm of oil. It would appear from this definition that the N.N. of an oil should be of real value in the study of petroleum oils. However, the N.N. of an unused oil is used to indicate the degree of refinement and amount of acids present; while in a used oil, the amount of acids present do not necessarily refer to its thermal decomposition or its corrosivity.

Carbon residue—Of no direct value or usefulness in hydraulics.

Color N.P.A.—Although in no way indicative of quality, useful as an index of control to both the refiner and the operator.

Figure 2 — Viscosity-temperature curves show different shapes when plotted on regular graph paper, and when plotted on logarithmic paper.


TEMPERATURE, DEGREES FAHRENHEIT
COMPARISON OF VISCOSITY-TEMPERATURE CURVE
OF 150 SUS @ 100°F. (100 V.I.) HYDRAULIC OIL
ON A.S.T.M. VISCOSITY-TEMPERATURE CHART &
ON REGULAR GRAPH PAPER.
150 SUS @ 100°F.

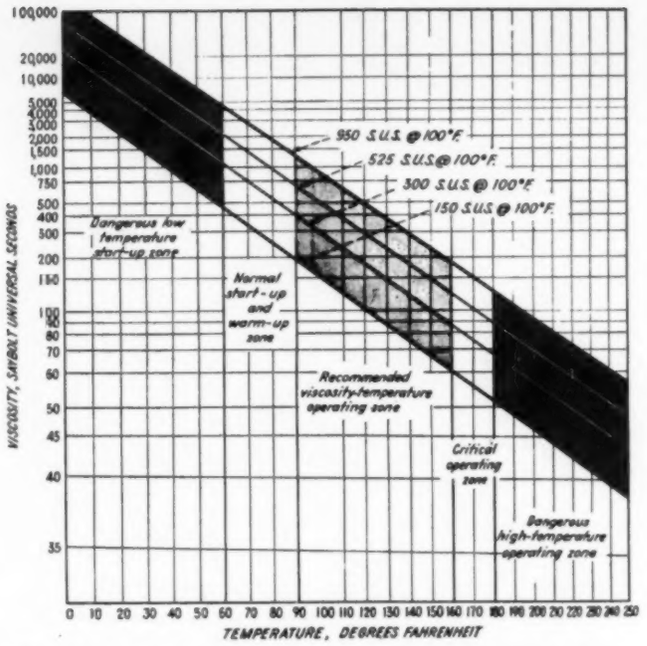

950 S.U.S. @ 100°F
525 S.U.S. @ 100°F
300 S.U.S. @ 100°F
150 S.U.S. @ 100°F
Dangerous low temperature start-up zone
Normal start-up and warm-up zone
Recommended viscosity-temperature operating zone
Critical operating zone
Dangerous high-temperature operating zone
VISCOSITY, SAYBOLT UNIVERSAL SECONDS
TEMPERATURE, DEGREES FAHRENHEIT

Figure 3 — Effect of temperature on the viscosity-temperature characteristics of hydraulic fluids in service.

Pour point—Degrees F—Pour point characteristics of no direct value to the industrial operator of hydraulics unless plant temperatures approach this value. More useful to the operator of outdoor equipment.

Let us now discuss the service properties of hydraulic oils. In discussing each service property it is hoped to give a thorough understanding and working knowledge of their importance, present methods of evaluation, and some of the current problems associated with them.

Viscosity—The first and most important task to be undertaken in selecting an oil for a specific circuit is the determination of the *proper viscosity* to be used in

TABLE III

VANE TYPE PUMP VISCOSITY REQUIREMENTS

Manufacturer	Operating temperature	Viscosity at 100 F
Racine Tool & Machine Co.	Above 60 F	200 S.U.S.
Rotary-vane type, variable displacement	Below 60 F Maximum operating — 160 F	75 S.U.S.
Vickers, Inc. Rotary-vane type, constant displacement	Ambient temperature 50-90 F Pressures above 500 psi with flow control valves. without flow control valves. Pressures below 500 psi with flow control valves. without flow control valves. Optimum operating — 135 F Maximum operating — 155 F	150 S.U.S. 225 S.U.S. 100 S.U.S. 150 S.U.S.

it at a specified temperature. This is of paramount importance as the transmission and maintenance of fluid power at maximum pressures is directly dependent upon the internal resistance that the viscous oil film offers to leakage. Viscosity, as it is known, also has a direct bearing on frictional losses throughout the circuit.

What is viscosity? How is it determined? Viscosity is a measure of the oils internal resistance to shear or flow at a definite temperature and pressure. Scientifically, the absolute viscosity of an oil is that force required to move a plane surface one sq cm in area over another plane surface at a velocity of one cm/sec when the two surfaces are separated by a layer of liquid one cm in thickness; i.e., dyne-seconds per sq cm. This unit of force is known as a poise, in deference to Poiseuille who established the equation upon which our present viscosimeters are designed. The term most commonly used is centipoises, or 0.01 poise. Although the absolute viscosity of an oil is scientifically expressed in poises, a definite relationship exists between absolute viscosity and its density whereby it is more convenient to express viscosity in units other than poises. By means of this relationship viscosity can be expressed in either stokes or centistokes.

Evaluation of viscosity—Instruments used for evaluating this physical property are known as viscometers or viscosimeters. These instruments consist essentially of a capillary tube through which a fluid may flow under certain constant conditions. Two of the most widely used instruments in this country are the Saybolt Universal Viscosimeter and the Modified Ostwald Viscosimeter.

Differences — Modified Ostwald Viscosimeter more accurate; results in centistokes whereas S.U.V. is in seconds.

Conversion chart—N.P.N.

Importance of viscosity—Primary value of viscosity is:

1. Control of fluid frictional and pressure losses.
2. Ability to act as a sealant and control leakage losses.

TABLE IV

AXIAL-PISTON PUMP VISCOSITY REQUIREMENTS

Manufacturer	Operating temperature	Viscosity at 100 F
Denison Engineering Co.		
High-pressure, high-volume constant-displacement, Type 3500 series.	Preferred: 110-130 F Maximum: 150 F	250-300 S.U.S.
LaPointe Machine Co.		
Variable and reversible discharge pumps.	Preferred: 130 F Maximum: 150 F	200-210 S.U.S.
Northern Pump Co.		
Axial parallel-piston, Series 7000.	Maximum: 160 F	450-650 S.U.S.
Vickers, Inc.		
Variable-delivery, piston-type fluid motor.	Above 500 psi — 50-90 F Below 500 psi pressure Maximum: 155 F	315 S.U.S. 225 S.U.S.
Waterbury Tool Co.		
Variable-speed transmission and variable-stroke pump	Preferred: 120 F Maximum: 150 F	320 S.U.S.

Frictional or pressure losses created by conditions conducive to turbulence as well as by excessive shearing stresses, are also governed by the viscosity characteristics of the hydraulic fluid. Consequently, it is not difficult to understand why there is one and only one viscosity that will give optimum results for a given circuit.

The following happens when an oil with too low a viscosity is used:

1. Increased oil leakage.
2. Inability to hold pressure.
3. Lack of positive hydraulic control.
4. Lower volumetric pump efficiency of increased pump slippage.

The following happens when an oil with too high a viscosity is used:

1. Increased pressure drop throughout the circuit.
2. Higher oil temperatures.
3. Sluggish hydraulic operation.
4. Lower mechanical efficiency.

Viscosity requirements—As the "heart" of any hydraulic circuit is its pumping unit, it will be found that the basic viscosity requirements have already been determined and established by the pump manufacturers. Although accurate and authentic, these recommendations serve mainly as a guide in arriving at the final viscosity.

Viscosity index—It is apparent that as the maintenance of a hydraulic system at its maximum peak of efficiency is dependent upon the presence of a viscous oil film between all moving surfaces, the fluid must, in addition to its viscosity, possess the greatest resistance to changes in "body" or viscosity with temperature.

TABLE V

RADIAL-PISTON PUMP VISCOSITY REQUIREMENTS

Manufacturer	Operating temperature	Viscosity at 100 F
American Engineering Co.		
Hele-Shaw pump.	Pressures below 1500 psi Below: 100 F Pressures above 1000 psi Maximum: 100 F Pressures above 1500 psi Minimum: 100 F Note: Minimum viscosity at operating pressure and temperature preferred.	 525 S.U.S. 860 S.U.S. 1250 S.U.S. 600 S.U.S.
Hydraulic Press Mfg. Co.		
Hydro-Power radial pump.	Preferred: 90-100 F Maximum: 125 F	900-1000 S.U.S.
Northern Pump Co.		
Series 5000.	Maximum: 155 F	650 S.U.S. 300-350 S.U.S. Min. at oper. temp.
Oilgear Co.		
Variable-displacement pumps and motors:	Max. preferred operating temp. — 140 F	
Type F — to 10 hp	55 to 170 F 40 to 70 F	550 S.U.S. 300 S.U.S.
Type C or D — 100 or 150 hp	55 to 170 F 40 to 140 F	550 S.U.S. 300 S.U.S.
Type C or D — up to 60 hp	40 to 160 F 25 to 135 F	300 S.U.S. 150 S.U.S.
Superdraulic Corp.		
Constant and variable-delivery pumps	Oil inlet temp. Maximum: 120 F Optimum: 90-100 F	150 S.U.S.

The term used to designate this physical characteristic is the hydraulic oil's viscosity index or V.I.

To fully appreciate and observe the changes which so take place in the viscosity characteristics of various hydraulic oils with temperature, it is only necessary to plot their Kinematic viscosity or S.U.V. at their respective temperatures on an ASTM Standard Viscosity-Temperature chart. The viscosities of an oil at temperatures other than standard instrument testing temperatures can be easily noted, as well as the relative rate of viscosity-temperatures changes of several oils.

As previously stated, a hydraulic fluid must possess the highest degree of resistance to viscosity temperature change if it is to assist in maintaining a circuit at its maximum peak efficiency. In other words, it must resist "thinning-out" or decrease in viscosity with temperature rise, and "thickening" or increase in viscosity with temperature drop. Because of its importance in hydraulics and in other forms of mechanical processes, a great deal of study has been given to evolving a method for rating this physical property.

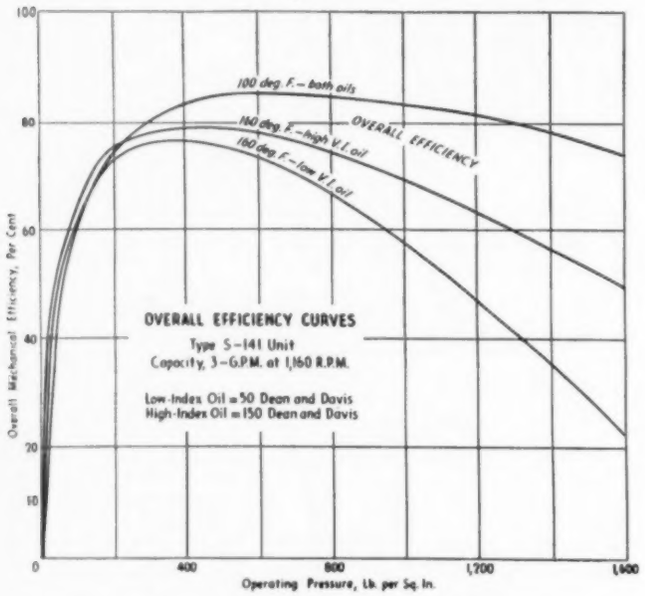


Figure 4 — The chart shows the effect of temperature and pressure on the overall mechanical efficiency.

Evaluating viscosity index—Present method based upon the original work of E. W. Dean and G. H. B. Davis.

Viscosity index of petroleum oils—According to our present interpretation of viscosity index, a perfect hydraulic fluid would be one which would have the same viscosity at all temperatures. Unfortunately, since such a fluid does not exist, a great deal of effort and research have been expended in this direction with the use of organic chemicals and additives, as well as improvements in the refining of petroleum oils.

Petroleum oils are adopted as the most universal type of hydraulic fluid because of their availability, low first cost, and ease of handling and application. In spite of these advantages, petroleum oils vary in their ability to resist temperature-viscosity changes. Origin of crude, its method of refining, blending, and subsequent processing, all have a direct bearing on the viscosity index of the finished product.

TABLE VI

PUMP MANUFACTURERS RECOMMENDATIONS FOR HYDRAULIC OILS

GEAR-TYPE PUMPS

Manufacturer	Operating temperature	Viscosity at 100 F
Brown & Sharpe Mfg. Co.		
Spur, spiral bevel, herringbone gear pumps	None specified	150-300 S.U.S.
Gerotor May Corp.		
Gerotor external-internal gear pumps	120-140 F	250-300 S.U.S.
Hydraulic Press Mfg. Co.		
Hydro-Power Gear pumps	.....	950 S.U.S.
Northern Pump Co.		
Series 4000 pumps:		
Small	.....	300 S.U.S.
Large	.....	500 S.U.S.
Geo. D. Roper Corp.		
Series F and H rotary gear pumps	180 F maximum	200-300 S.U.S.
Sundstrand Machine Tool Co.		
Type WX Rota-Roll pump	120 F preferred	155 S.U.S.

Importance of viscosity index—The importance of the viscosity index characteristics of a hydraulic oil is evident from a study of this ASTM Viscosity-Temperature chart where in the "Effects of Temperature on the Viscosity Characteristics of 100 V.I. Hydraulic Fluids in Service" are noted. Five rather specific zones of hydraulic operations have been indicated after years of field research and cooperation with the manufacturers of hydraulic pumps and equipment.

"Low temperature start-up zone" — danger zone — Due to increased oil viscosity, and frictional losses, pumps rattle and are very noisy. Most serious effects are scoring and excessive pump and valve wear due to lubricant starvation.

"Normal start-up and warm-up zone"—Practically all industrial hydraulic equipment starts up in this temperature zone. The smaller the difference between the normal start-up temperature and the mean operating temperature, the less time is required or lost during the "warm-up."

"Recommended viscosity-temperature operating zone"—Most important zone. Devised from compilation of the temperature ranges which the pump manufacturers recommend for optimum efficiencies with their equipment. Very useful in determining proper viscosity for certain circuits.

"Critical operating zone"—This is critical because of:

1. Effect of temperature on oxidation stability.
2. Effect of temperature on accuracy and efficiency of machines.
3. Effect of temperature on viscosity of fluid, and volumetric efficiency of pump.

"High temperature operating zone"—Dangerous as far as pump "life" and efficiency is concerned. Poor hydraulic control as well as chatter and vibration. Very destructive on stability of fluid.

Effects of low V.I.—More critical in each zone.

Demulsibility—As conditions within the average hydraulic system are conducive to the precipitation of moisture and the formation of stable water-in-oil emulsions, a hydraulic fluid must possess the ability to separate rapidly and completely from this form on contamination. It must also resist emulsification as well. This important physical property is usually referred to as its demulsibility characteristics.

Contributing causes to condensation and moisture are temperature differences and constant air leakage into the circuit. Other causes of moisture are leaking oil cooler, and seepage of coolant because of improper machine design. Formation of stable water-in-oil emulsions is attributed to the ideal homogenizing action of the pump on the water and oil mixture.

Our interest in the D.C. of an oil is due to the possible effects of both the free water and the absorbed water on not only the life-expectancy of the fluid but on its service performance characteristics as well. An outline of these effects are:

1. Destruction of fluid's lubricating value.
   a. Increased frictional losses.
   b. Increased pump and valve wear.
   c. Increased packing troubles.
2. Destruction of the fluid's sealant properties.
   a. Increased pump and valve leakage.
   b. Erratic valve and pump operation.
3. Increased oil and metal chemical activity.
   a. Destruction of the fluid's resistance to oxidation and emulsification.
   b. Promotion of rust and corrosion.

Evaluating the D.C. of an oil—In evaluating the D.C. of an oil, our primary interest is in those compounds, whether organic or inorganic, that are hydrophilic in nature and have a direct influence on this important physical property. As is known, highly refined oils are composed of hydrocarbons which are basically hydrophobic in nature and contain, if any, an extremely small amount of hydrophilic compounds. It is also known, that as petroleum oils oxidize in service that hydrophilic compounds are produced.

Moreover, with the increase of such compounds, the interfacial tension of the oil against water is decreased. It is possible by means of either the capillary method or the ring method to measure this change in interfacial tension very accurately. Although not an ASTM test the ring method using the duNouy interfacial tensiometer shows definite promise as a means of determining the "life-expectancy" of an oil. Force required to pull a platinum ring through water-oil interface is recorded in dynes/cm.

Other demulsibility tests—S.E. No.—Of no particular value here. Herschel demulsibility—Debatable.

Oxidation stability—The ability of an oil to resist both polymerization and thermal decomposition in the presence of air, water, heat and dissimilar metals is termed oxidation stability. The greater its resistance to changes in its original physical and chemical structure the higher its stability. Experience has shown that the stability of a hydraulic fluid is governed by two very important factors, viz:

1. *Composition of the fluid*—Crudes from which it is made (Penna. M-C, naphthenic); its method of refining (conventional or solvent-extraction); and its subsequent treatment with additives such as oxidation inhibitors.
2. *Conditions under which it must function*—Temperatures; pressures; extrinsic contaminants; and, reactive metals.

a. Temperature—Optimum Range 110 to 130 F.

Source—Energy absorbed at pump; friction in lines, valves, elbows, "wire-drawing" through valves; "oil-shearing," turbulence.

Effects—Polymerization and thermal decomposition.

Polymerization—oil thickening.

Thermal decomposition — lacquer and varnish, sludge, etc.

Results—Sluggish operation.

b. Extrinsic contaminants — Contaminants from sources other than oil.

Contaminants—Entrained water, coolants, threading compounds, grease, paints, core sand, drawing compounds.

Causes:

Effects—More detrimental to surface finish; scored and corroded parts; increased machine down-time, etc.

1. *Machine design*—Protection against entrance of coolants, dirt, water, efficient filters.
2. *Proper material standards and controls*—Would eliminate the use of uncleaned pipe, and poor

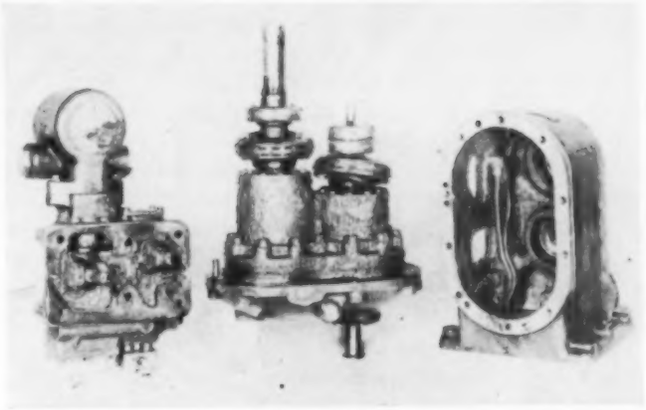
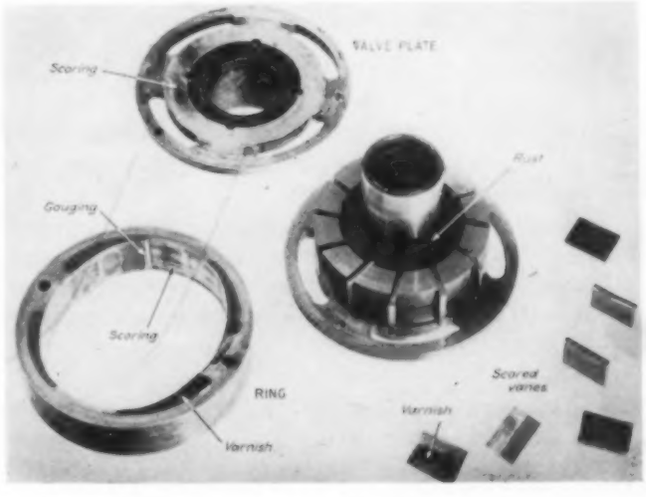


Figure 5 — Because of the break-down of the hydraulic oil, sludge formed in this pump.

Figure 6 — Pump failure was due to the pressure of water in the hydraulic fluid.



types of metal finishes within circuit during assembly.

3. *Preventive maintenance schedules*—Would eliminate use of wrong oil; minimize leakage; deteriorated seals, etc.

c. *Reactive metals* — Catalytic effects on metals. Copper and its alloys greatest effect; Zn, Pb, Fe, Sn, and Al. The presence of water and elevated temperature are also serious.

d. *Operating pressures* — Viscosity increases with pressure. Frictional losses are proportional to viscosity. Therefore, increased pressures mean greater frictional losses and higher operating temperatures. Pressures below 1000-1500 psi are not critical.

Oxidation tests — There is no accepted laboratory test. Automotive oil tests such as Underwood, Sligh, Continental, etc., are of little value. Research is under way for new method. ASTM "Proposed Method of Test for Oxidation Characteristics of Steam Turbine Oils" is best to date. Oil oxidized at 95 C in presence of water and Fe-Cu catalyst with pure O_2 at a definite rate. Test is stopped when N.N. is 2.0. Oil's service life is given in number of hours. Test is qualitative not quantitative.

The primary function of hydraulic oil to transmit power where it is required. Of equal importance, is its ability to function as a lubricant, i.e., when interposed between surfaces in relative motion, it must prevent metal to metal contact, minimize friction and prevent seizure and wear. Moreover, to function as a *lubricant* in a hydraulic circuit, an oil must possess two important characteristics; proper viscosity; and lubricating value.

1. *Proper viscosity*—Its value has been already discussed—maintaining hydraulic circuit at maximum peak of mechanical efficiency, minimum pressure losses and maximum pump volumetric efficiency. Of interest in hydrodynamic lubrication.
2. *Lubricating value* — When changes in viscosity cease to minimize frictional losses and wear begins to become a problem, the oil's LV assumes major importance. Why should we be interested in this when all of the working surfaces are constantly operating in oil? Worn parts, etc., and operating conditions are not always favorable to the formation of thick oil films, and there may be boundary lubrication. The necessity for lubricating value in boundary friction is to minimize those frictional losses due to:
   a. Interlocking or "clutching" of surface asperities —Coulomb's theory.
   b. Fields of force attributed to molecular attraction and adhesion between two moving surfaces—Hardy's theory.

It has been proven that the ability of an oil to perform satisfactorily under conditions of boundary lubrication is due to the oil's chemical nature and its chemical affinity for metal. Lubricating value is dependent upon three factors:

1. Oiliness.
2. Extreme pressure or anti-weld properties.
3. Composition of rubbing surfaces.

Oiliness—Oiliness is that chemical feature of an oil which permits it to "wet" metallic surfaces and establish a minimum c_f under conditions of boundary friction. Ability of an oil to "wet" metal is due to presence of certain organic compounds which have a definite affinity for metal known as oiliness agents. Animal and vegetable oils exhibit greater degree of oiliness than mineral oils. It is a definite benefit to hydraulic oils. There are no accepted test standards. Entire subject is still theoretical.

Value of oiliness in hydraulic fluids

a. Insures presence of thin protective film on metal surfaces at all times.
b. Reduces starting torque.
c. Minimizes frictional losses and wear.

Extreme pressure or anti-weld characteristics—Ability of oil film to resist rupture and prevent seizure under conditions of high unit pressure and temperature is attributed to presence of certain organic compounds and their increased chemical activity under extreme conditions of boundary friction. These are known as extreme pressure additives. Their action is due to S, Cl, P.

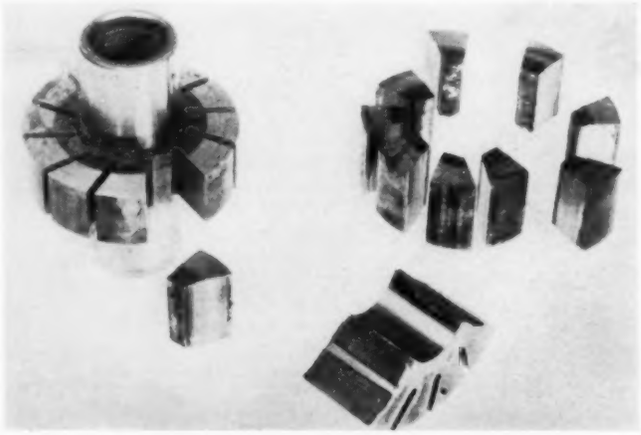
Evaluation — Timken, Almen, Falex, S.A.E. and Shell four ball testing machines are used. The ultimate load, as evidenced by either seizure or excessive wear, is used as an index of the load-carrying capacity of the oil. Widely divergent values are obtained and no two machines rate oils in same order. The reasons are due to basic differences in design and operation. Tests are of definite and useful value.

Importance of EP characteristics — Evidenced by worn and scored pumps, valves, etc., EP conditions exist at:

1. Edge of vanes and rings.
2. Between mating gear teeth.
3. Between connecting rod and piston (axial).
4. Between piston and wobble plate (axial).
5. Between rotary valve plate and housing.

Hydraulic oils characterized by high oiliness and EP properties are of real value in new equipment. B. W. Sakman work on the "Geometrical and Metallurgical Changes in Steel Surfaces Under Conditions of Boundary Lubrication" illustrates this point. The value of superfinishing is illustrated in Mr. A. M. Swigert Jr.'s "Graph of Wear Zones."

Figure 7 — The rotor failed because of water in the hydraulic system.



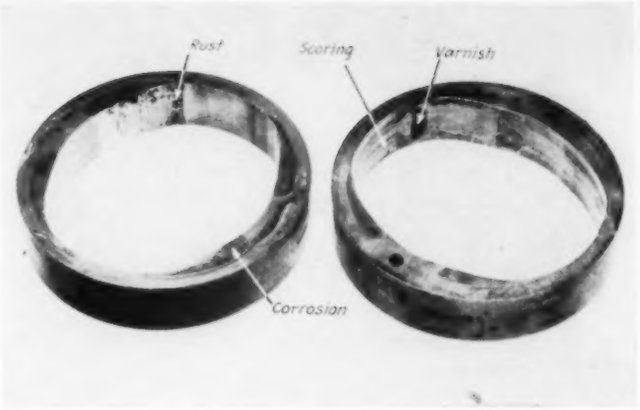


Figure 8 — Illustration shows pump ring failure.

As illustrated, the lubricating value of an oil is governed by its oiliness factor and extreme pressure qualities. An oil with a high lubricating value assures lower starting torque; less frictional losses; minimum pump and valve wear; protection against seizure, and longer pump and valve life.

Rust and corrosion preventive qualities—To be successful as a hydraulic fluid, an oil must also possess the ability to protect metal working surfaces against rust and corrosion. The necessity for this protection is due to the adverse affect of these two reactions on the "wear-life" of the metals and the "life-expectancy" of the hydraulic circuit. The following is a definition of rust and corrosion: Rust is considered to be a form of corrosion. However, as a matter of simplicity, rust is an oxidation reaction and is reflected in metal growth; whereas, corrosion, is the effect of acids on metal and is reflected in metal loss.

Rust is the result of water or air on iron.

Objections:

1. Destruction of surface finish and "skin." Increased frictional losses and wear.
2. Surface growth and clearance reduction. Increased rate of wear and possible scoring.
3. Clogging of fine orifices and possible scoring of highly polished surfaces by abraded rust particles in the oil stream.

There is a definite need for processing all hydraulic oils with rust preventives. ASTM Test—Rust Preventive Characteristics of Steam Turbine Oils in the presence of water (10 per cent water and 90 per cent oil at 140 F for 48 hours—steel rods).

Corrosion

Causes—

Acids from the oxidation of the oil attacking metal surfaces in presence of peroxides, etc.

Objections—

1. Destruction of surface hardness and "skin" by pitting and etching—fatigue failures.
2. Increased surface roughness—accelerated rate of wear.

This condition is corrected by means of oxidation inhibitors.

The following summarizes desirable hydraulic fluid service properties:

1. Proper viscosity.
2. High viscosity index.
3. Positive demulsibility.
4. Oxidation stability.
5. Lubricating value.
6. Rust and corrosion preventive.

DISCUSSION

PRESENTED BY

N. I. WHITELEY, Lubrication Engineer, American Steel and Wire Co., Cleveland, Ohio.

A. J. ZINO, JR., Swan-Finch Oil Corp., New York, N. Y.

N. I. Whiteley: Do you have a hydraulic fluid for the door extractor on a coke oven? I made an investigation into that and to date I have not found anybody making a non-inflammable hydraulic fluid for a door extractor mechanism that could operate a pump at low temperatures. The people in that field today are primarily working on aviation products, and also die-casting which involves room temperatures for operation. When you figure on a door extractor operating at temperatures as low as 20-30 degrees below zero, you can find fluids that will flow at those temperatures, but at the operating temperatures they will not run the pump.

A. J. Zino, Jr.: No, we have not. The oil found useful in those coke oven doors is actually a solvent-extracted naphthenic oil. Unfortunately, it does not completely solve the door extractor problems. Naphthenic oils available, without V.I. improvers, have V.I. ratings of 40 to 60. Of course, your interest in the viscosity index characteristics of the oil is actually for only about 15 to 20 minutes. Thereafter, you are only concerned with the final "body" or viscosity of the oils.

Unfortunately, low V.I. oils do offer a problem in that they have a very high leakage factor. There is very little you can do about this. There is one possible exception to this and that is the use of heat-control units. That, of course, is an expensive proposition.

N. I. Whiteley: I was interested in a safety fluid, where, in the case of breakage in the hydraulic line, the man operating the door extractor up on the platform would not get burned with oil. I would like to get in touch with the people who make this type of oil.

A. J. Zino, Jr.: Mr. Whiteley, there are several such oils available where fire is a serious hazard. Among these are Monsanto Chemical Co.'s Arochlors and Celanese Chemical Co.'s Lindol. They do have excellent fire-resisting properties, but rather low V.I. ratings. Another type of fluid which offers excellent possibilities is the synthetic water-type hydraulic fluid. Here we are dealing with water and organic chemicals in a solution and in order to get all of the essential properties for hydraulic operation, a very delicate chemical balance exists between the various ingredients. As you know, water has a certain vapor pressure and as it starts to evaporate at higher temperatures, this balance can be upset. Hence, other problems which might be as serious as a fire hazard can be affected.

Dry Cleaning With Corn Cob Grits

By EDGAR W. SHOFF
General Foreman, Electric Shop
Gary Sheet and Tin Mills
United States Steel Co.
Gary, Ind.

. . . . corn crib grits form an effective and safe method for cleaning electrical and other equipment . . . .

▲ THE introduction of corn cob grits as an abrasive material in the cleaning of electrical equipment resulted principally from the efforts at Gary Sheet and Tin Mill to reduce or eliminate altogether certain fire hazards and toxic effects encountered when liquid solvents are used.

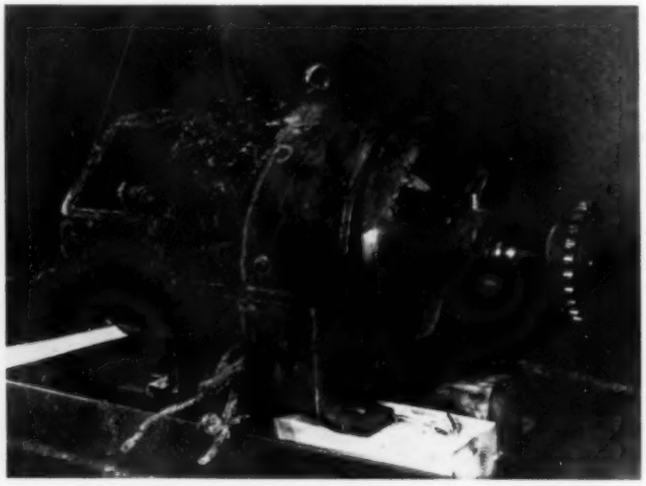
The use of corn products, though not entirely free from elements that must be controlled, was investigated. It was found that corn cob grits yield of soft pellet which has fine cleaning qualities, entail a lesser degree of fire hazard than petroleum-base solvents, leave no toxic effects, and are non-corrosive. They have also reduced the amount of time a piece of equipment is out of service and have effected a substantial saving in labor and in the cost of cleaning materials.

Our first application of a corn product as a cleaning agent was made early in 1944, using corn meal. The advantages of this were such that within a year this method of cleaning had practically replaced all others for work on jobs of any size outside of the shop. However, in using corn meal we were confronted with the necessity of carefully controlling such factors as moisture in the meal which caused it to become lumpy and to clog the machine; the attraction of rodents and insects in large numbers; and, since it had to be kept dry, the excessive dust created by its use.

Although corn meal was highly satisfactory as a cleaner, the difficulty encountered in effecting the necessary controls eventually led to the substitution of grits from corn cobs, in 1948. It was found that this material did an excellent cleaning job on electrical equipment and did not have the objectionable features of corn meal. Corn cob grits have also been used effectively in cleaning bearings, viscolite coated gears, and

Figure 1 — Fifteen horsepower motor is shown before cleaning.

Figure 2 — This is the same motor shown in Figure 1, but right half of motor has been cleaned with corn cob grits.



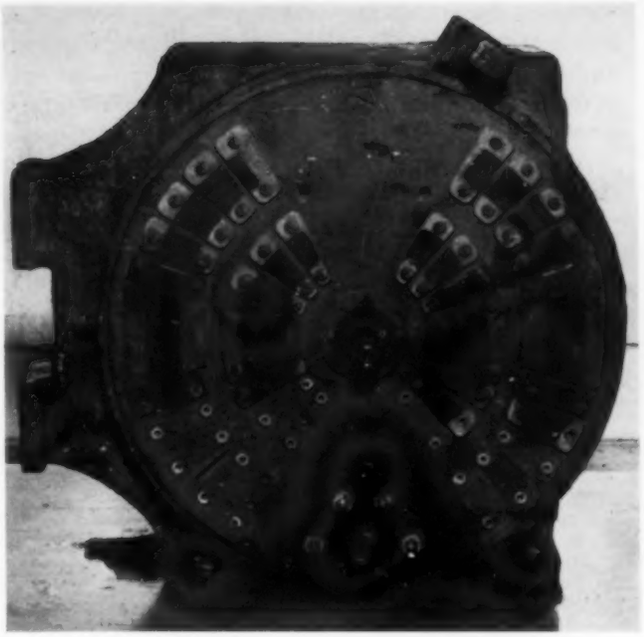


Figure 3 — Overhead electric crane controller is shown dirty before cleaning.

Figure 4 — No. 20 mesh corn cob grits were used to clean this overhead electric crane controller.

in the removal of various types of dirt from other equipment.

NATURE OF EQUIPMENT

The first equipment was very simple and consisted of an air suction gun, a length of hose, and a bucket of corn meal. After the results derived from corn meal were evaluated, a more substantial machine was constructed, involving the same principles, but also embodying a hopper which held approximately 100 lb of corn meal. This equipment was used to clean all types of motors and generators.

In 1949, a portable blast machine using corn cob grits appeared on the market, one of which was purchased by Gary Sheet and Tin Mill. At the outset it was necessary to make some alterations to the machine to get the desired performance. This resulted in equipping it with an agitator, to keep the grits circulating in the machine, and the installation of regulator valves to maintain a steady flow of grits from the machine and to control the volume used.

This "Corn Cob Machine," as it is now frequently called, employs the same principles used in sand blasting. That is, a stream of air at relatively high velocity, containing an abrasive, in this case corn cob grits, is used. The machine contains a tank, the lower portion of which is cone shaped and ending in a vertical orifice. This orifice is constructed from a rubber ring which contracts under pressure applied by the abrasive flow regulator to provide a variable round hole through which the abrasive flows. A slide is also provided to cut off the flow of abrasive when it is necessary to use a stream of compressed air alone. The air supply, which may be taken from the normal plant supply of medium pressure compressed air, passes through a moisture and oil separator to prevent clogging of the machine. Following the separator there are two valves, one of which regulates the air flow to the agitator while the other regulates the pressure, or flow, through the mixing chamber below the orifice.

The agitator is built into the machine near the base to keep the grits from bridging and packing. It also provides a means of directing the grits through the orifice to the mixing chamber. The air that passes through the mixing chamber picks up the corn cob grits, conducts them through a hose and out the nozzle and against the surface that is being cleaned.

OPERATING THE CORN COB MACHINE

In cleaning equipment by the above described process, the nozzle should be held from one to two feet from the surface to be cleaned. For removing heavy grease at high speed, a small flow of grits at high pressure is used. For removing light oil film and other delicate work, a heavy solid flow of grits at low pressure is used. This results in a wiping action with high absorbing and little blasting effect.

In cleaning large motors and generators, we have found it advisable to arrange a large canvas canopy over the machine for the purpose of confining the abrasive materials to the cleaning area, thereby preventing their dissemination throughout the general room atmosphere. The operators each wear a dust hood, which combines a respirator and safety lenses for their protection against the dust. The respirator keeps the air supply dust-free with little resistance to breathing.

Usually, two men are necessary for each cleaning crew, with crews alternating about every fifteen minutes. One man does the actual blasting while the second checks on the thoroughness of the cleaning and arranges the lights around the cleaning area, thereby providing continuous operation. After the dirt and

Figure 5 — The stator windings of this 8400-hp motor were very dirty before cleaning.

grease have been removed, the abrasive supply is cut off and compressed air alone from the blast nozzle is used to blow off any remaining particles of abrasive. The used abrasive can be picked up with a vacuum cleaner and used for other purposes, such as a floor sweeping compound.

The electric shop has included in their shop equipment a permanent type canopy complete with an exhaust system under which all small work may be thoroughly cleaned. With this arrangement, the operators wear dust hoods (combination dust hood, safety lenses and respirator). The erection of a canvas is not necessary.

The operator of the blast machine should exercise caution in applying the blast stream to the surface, especially when cleaning electrical windings, because continuation of the blast after the removal of all foreign matter could damage the insulation. It is, therefore, desirable that the operator have a good understanding of both the operation of the blast machine and the equipment he is cleaning. Although provision must be made to protect the crew from dust, and they should avoid the direct force of the blast, the operation is considered a safe and very effective means of dry cleaning.

Figure 6 — After cleaning with No. 20 mesh corn cob grits, the stator windings of the 8400-hp motor are shown to be quite clean. Note also there appears to be little damage, if any, to the insulation.

ADVANTAGES OF THE CORN COB GRITS METHOD

We have found a number of important advantages in using corn cob grits in cleaning electrical equipment. Chief among them are:

1. It eliminates possible toxic and flammable fumes produced by liquid solvents.
2. The grit cleaning method is faster.
3. The amount of time the equipment is down is reduced very appreciably since there is no drying time required and generally less dismantling of the equipment for cleaning and consequent reassembling.
4. The cost of the corn cob grits needed, at about two cents per pound, is only a fraction of the cost of liquid solvents required for the same job.
5. There is an important saving in man-hours of labor, as well as production time.

DISCUSSION

PRESENTED BY

A. J. WHITCOMB, Electrical Engineer, Freyn Engineering Co., Chicago, Ill.

EDGAR W. SHOFF, General Foreman, Electric Shop, Gary Sheet and Tin Mills, United States Steel Co., Gary, Ind.

K. A. DAUGHERTY, Electrical Engineer, National Tube Co., Gary, Ind.

VICTOR E. HOLTSLANDER, General Electrical Shop Foreman, Inland Steel Co., East Chicago, Ind.

KARL J. DOLL, Superintendent Pittsburgh Service Shop, General Electric Co., Pittsburgh, Pa.

RICHARD THOMAS, Electric Shop, Gary Sheet and Tin Mills, Carnegie-Illinois Steel Corp., Gary, Ind.

FRANK NEWELL, District Sales Engineer, Pangborn Co., Chicago, Ill.

FRANK L. GRAY, Lubrication Engineer, Gary Steel Works, Carnegie-Illinois Steel Corp., Gary, Ind.

A. J. Whitcomb: I was very much interested in Mr. Shoff's novel method of cleaning electrical equipment and one of the reasons was on account of a rather odd application of something similar for cleaning automobile windshields. Whenever I go through Fremont, Ohio, I stop at a gasoline filling station that always takes the bugs off the windshield with a wet corn cob. There is some peculiar action in a wet corn cob on a wet windshield that will take the bugs off in nothing

flat and leave it very dry, clear and glistening.

I am wondering why the application of this is not extended further than just cleaning electrical equipment? Is there some reason why it is not applicable to cleaning other equipment? And where do you get your corn grits? Do you manufacture them yourself? Do you cut them up yourself or grind them up or buy them as such?

Edgar W. Shoff: We buy them as such. There are other materials, but sawdust is the next best thing we have tried out on gear housing and gears. We find that it is very good, and you can buy the sawdust with very little dust in it, we find it is very suitable for that purpose which we are going to use later on as a permanent method instead of using solvents. No. 20 grit is about the best we can get for electrical equipment. But, you can use a heavier grit. No. 10, that may do the work too, if you did not want to use sawdust. However, I still say it is one of the best methods we have found yet, and it is a safe method as far as the steel industry is concerned.

K. A. Daugherty: Mr. Shoff is to be congratulated for for the research work he and his company have done to get this corn cob or grit cleaning before us. Our company has one of these machines and it is doing an excellent job. You can clean almost anything that has dirt, oil, or grease on it. It does, however, have some limitations on motor or generator windings which are oil soaked. Usually, in that case, the job is ready for a rewind anyway. One of the most important jobs it can do is on large machines over the week-end which can be dry cleaned, blown off with air, painted and put back in service on Monday morning. When we clean with a solvent, we have the danger from toxic fumes. Then the solvent must be cleaned off with pure carbon tetrachloride to get machine dry. This is expensive, dangerous and time consuming.

Victor E. Holtslander: We have used the dry cleaning method in our plant for a good many years and have met with quite a degree of success. However, we have not used corn cobs. We have used tin mill bran which has more or less of a flour content, and it has been quite successful. Recently we purchased some No. 20 grit corn cob and our boys have tried it on major drives, we have found that the corn cob material, being more coarse is not nearly as absorbent as the more powdery form of material. However, the more powdery the material is, the greater the dust around the rest of the room. We have tarpaulins to cover the rest of the equipment, but with labor at a premium today, the cleaning of the motor room and the equipment is a problem.

Another question that enters into the use of corn cob grit for cleaning is the abrasiveness of the material. Of course, I think you will all agree that roll drives are maintained, cleaned and varnished quite often so these installations are in pretty good shape and the slightly more abrasive condition of the material used is not so great as to ruin the insulation of the motor. However, this must be watched very closely.

I would like to ask, if in the operation in the shop, he has had any experience for instance, with general purpose Class-A motors? We realize that once in a while we get a motor in the shop that should have been sent in earlier, and perhaps the insulations are deteriorated. If we were to blast a machine of that nature, we would have nothing left but bare copper. To what extent do you use the blasting method on machines of this nature?

Of course, we realize Class-B insulation with glass and asbestos tape will take more abuse than the Class-A insulation. We have not done too much of it in our shop. We have used other methods of cleaning, but we are considering going to this type of cleaning in our shop, and it would be of interest if we could hear about any experience the author has had on this method of cleaning.

Edgar W. Shoff: Our electrical engineer told me some years back that the motors we are buying now are Class-B insulation, and the quicker we can get rid of Class-A, the better it will be for the sheet and tin mill. If we get a job that is dry and I do not think it will stand a good cleaning, we strip the job and rewind it with Class-B, which our electrical engineer recommends and we try to follow that out.

Victor E. Holtslander: You realize it will take a few years to replace the Class-A windings with Class-B material? When you have 15,000 motors or more in service, it would require a long range program to renew all windings with Class-B insulations. The cost of such a program would also be another item. We are of the opinion that Class-B insulation is not essential in all cases.

Edgar W. Shoff: We have a modernization program at our plant and it is not over yet, but I believe the majority of our Class-A motors have been sold or scrapped. There are not too many left.

Karl Doll: I was greatly interested in your message. For many years we have cleaned large electric equipment in steel mills using solvent cleaner. We are fully aware of the ever-present danger of fire and toxic hazards with this cleaning method, and when we first heard about the "corn cob" cleaning method, we thought it was the answer to a "maiden's prayer." We bought one of the corn cob cleaning units and experimented with it for three months (nothing in relation to your six years) on all types of electric equipment. However, we ran into three major difficulties which finally forced us to discard this cleaning method:

1. Compressed air in itself will do serious damage to a dry and brittle winding. If an abrasive like corn cob is introduced into this air stream it amplifies the damage.
2. A baked dirt deposit, formed by oil fumes and dirt, is very difficult to remove without damage to the winding. We literally ripped insulation off the conductors and even so were not able to remove the caked-on dirt.
3. This method will not clean such inaccessible places as the underside of coils, back V rings, back side of equalizers and in air ducts.

Now, I would like very much to hear your experiences on those three items; the first of which is on the dry and brittle winding, and secondly, on windings where the dirt has been baked on in a solidly caked form and third—how to clean inaccessible corners.

Otherwise, for new windings or oil soaked windings, I think it is a splendid process.

Edgar W. Shoff: What kind of grits were you using?

Karl Doll: The No. 10 mesh.

Edgar W. Shoff: Well, that is not good. You should not use No. 10 grit. That is the wrong size grit for electrical equipment. No. 20 is the proper grit. You gave the machine to your Chicago shop and they still have it. We showed them how to use it.

Karl Doll: On baked dirt deposits, we tried it on five machines. We experimented with different pressure, different distances of nozzle and winding and I know of cases where we cut off on the 6600 volt machines.

Edgar W. Shoff: With No. 10 grit?

Karl Doll: That is half of it. We were unable, in spite of it, to remove the caked-on dirt. As a matter of fact, the caked-on dirt on the run off edge was removed only one-eighth of an inch below where we cut insulation.

Edgar W. Shoff: However on insulation on mill drive motors, which are usually oily and greasy, or air compressor motors which are extremely dirty, you have to use a lot of corn cob grits and not too much air pressure. Increase the flow of cob grits and you will eliminate your grease and dirt. That is our practice.

Richard Thomas: I would like to come to Mr. Shoff's aid with a few words of explanation regarding cleaning of old machines, or other special cases, that require special treatment, and variations of air pressure and amounts of cleaning grit to accomplish the desired result. In the case of an old machine, in which the insulation could be easily damaged, larger amounts of the cleaning grits are induced in the air stream and the air pressure is reduced. The opposite technique is used for hard to clean equipment or windings that are in good shape and can stand higher pressure or more severe blasting. For example, we recently brought a 100-kw generator into our shop from the continuous pickler, that was literally soaked with acid, and extremely dirty, and tested 1500 ohms to ground. In this case we used an air blast of 40 psi with the least amount of No. 20 grit possible to get a cleaning action. When the cleaning was finished, and before placing the generator in the drying oven our megger reading was 500,000 ohms to ground.

In answer to the gentleman from General Electric Co., I would like to state, that we too had some difficulty at first with this method, in getting our men to use it, and to use it properly. However, with a little training and experience, we quickly developed several operators; and other plants and shops have done likewise. Naturally in cleaning electrical apparatus, persons with some knowledge of that equipment and the values of insulation are required. From our experience it is evident the average shop electrician, with a little instruction, and experience with the method, can clean practically any electrical apparatus better, quicker, and safer, than with liquids or solvents, such as are commonly used for that purpose. I will admit we have knocked off some insulation on old machines in which the insulation was dry and cracked but we have never damaged the insulation seriously enough that it could not be repaired with a little tape and paint.

Also in reply to some of the inquiries it is not to be expected that one size of corn cob grit will clean everything. While No. 20 grit seems to be quite satisfactory for cleaning the general run of electrical windings, finer or coarser grades may be required in some cases. In removing heavy oil and greases such as crator compound, No. 10 grit under high pressure would be required, and I am now thinking of cleaning gears or things of that nature. It is my firm belief that with a little experience, and experimentation with the finer and coarses grades of corn cob grits, or other grit material which would be suitable for the application involved, almost anything can be cleaned quickly, effectively and safely, with the method described by Mr. Shoff.

Frank Newell: I was at the demonstration here in Chicago on the machine that was turned down in Pittsburgh, and as they said, they did clean the generator without hurting it. Well, as soon as the machine came in, we knew what the trouble was. They had started with the No. 10 corn cob which was found unsatisfactory for cleaning any type of motor winding. No. 20 is a fine material and we have found by throwing a heavy flow or concentration of corn cob grits into the air stream you can clean pretty delicate windings without hurting them, where on the other hand, if you cut the amount of corn cob down in the air stream, you will have a harsh blasting action and you will cut them.

If you want a harsher cleaning, use a No. 20 corn cob grit, and it will remove hard deposits very readily without any trouble.

Mr. Shoff bought the first machine. Mr. Dougherty bought the second. Since then, a number of others fell into line. Mr. Shoff was the man who started us on the corn cob equipment and he made improvements on the machine. The first one did not work and we had to take them back and develop the present machine by adding Mr. Shoff's improvement. These machines are on the market and pretty well proven.

Frank L. Gray: We have been cleaning exhaust valves on our gas blowing engines by using a caustic. We want to get rid of that. Other methods are contemplated. It is a dirty air with oil formation baked on under possibly 260 to 300 F temperature and baked on in layers as was explained in the electrical windings under heat. We have one of these machines and maybe we ought to take one of these valves over to find out how to clean it. It sounds like a good idea.

Edgar W. Shoff: Mr. Gray, I would like to try that out with sawdust. I really believe it would work.

Member: What you are talking about has been used by the Air Force. They have been cleaning carbon from pistons and exhaust valves on air craft for the last seven or eight years. It is adopted as standard by the U. S. Air Force, so it is not a new application at all.

Frank L. Gray: We have a better method, but there is some objection to the better method. Caustics are hazardous. Carbon tetrachloride is dangerous. Tetrachlorethylene or trichlorethylene have been proven to be toxic. We have better methods but what we want are safer methods and there has been nothing suggested that is safer. We have gone away from the mineral spirits, the caustics and the toxics when we go to corn cob cleaning.

LUBRICATION OF WIRE ROPE

By JOSEPH A. RIGBY
Vice President
The Brooks Oil Co.
Pittsburgh, Pa.

. . . . wire rope demands exacting requirements of the lubricant . . . .

▲ WIRE rope should be classified as a machine designed and manufactured with precision and exactness. Actually it is a precision machine with parts in sliding and pressure contact, thus requiring lubrication for protection against wear. Exposed to all types of weather in moisture and vapors, a corrosion factor is prevalent imposing the problem of protection. In all probability, and in most installations, wire rope is abused to a greater extent than any other form of mechanical equipment. As a consequence, lubrication becomes the prominent factor in satisfactory service of the rope.

Lubrication may be divided into two classifications: lubrication and protection. It should be clearly understood while "good lubrication" usually affords some corrosion resisting protection, "good protection" does not necessarily insure thorough lubrication.

The function of a lubricant is to provide a film covering of the bearing surfaces to preserve the fabric or steel center, so that the elasticity and resiliency may be retained, and to prevent the formation of "corrosion pitting" which will quickly break down the original physical properties of any wire.

A protector is used to preserve the lubricant, and to seal the rope in order to prevent moisture and corrosive influences from penetrating into the rope. Wire rope in service will only produce their best values and endurance with proper care and with efficient lubrication.

Expected life of wire rope aside from proper care is affected greatly by variables such as load factors, speeds, shock conditions, and contamination action by water, acids, salt water and atmospheric elements, as well as metallic and other dusts adhering to the rope. The greatest factors contributing to short life in wire hope are corrosion, abrasion and frictional wear. Resistance to these factors can only be accomplished by lubrication of the rope in the manufacturing process and in operational or maintenance service.

Correct lubrication of wire rope should be with a lubricant having the following essential characteristics: adhesiveness to metal, high film strength, water repellence, corrosion prevention, compounded stability, heat resistance, resistance to salt water and acids, flexibility at low temperatures, imperviousness to other lubricants, solvency for removal in cleaning, simplicity in application, protection of fabric core without deteriorating effects, and sealing of the rope to prevent infiltration of foreign substances to the strands and core.

In forming the rope, lubricants are used to provide initial protection against friction of the wires and strands in service, and corrosion in shipment and storage. Ordinary lubricants, which have been used, have been helpful; but have left much to be desired in efficient operation. Some lubricants are advantageous in low cost, ease of application and possess some degree of lubrication, but lack the resistance to abrasion, moisture, acids, extreme pressure, heat and other factors. Invariably, the lubricants are wiped off in handling, washed off by water or drip off from heat or volatilize.

The manufacturers of wire rope have been alert to the problems of operational service and by a conscientious policy have consistently experimented and now use improved lubricants having the desirable characteristics previously described. The problem then depends on the user of the rope applying compatible lubricants, preferably of identical nature in extending the rope service to an economical advantage.

Oils or fluids are available with desirable characteristics, are easy to apply by simple methods, have the best qualities in penetration, good coverage of all surfaces, and provide negative corrosion effects, but which have excessive drippage and require frequent applications.

Greases or plastic lubricants in N.L.G.I. cup grades of No. 1 or 2 consistency of leaded compounds with high adhesiveness, water repellence and extreme pressure film strength, have been effective and economical in service with many years of substantiating proof in results. These are easy to apply by brushing, swabbing or air spraying methods to the drum and to the portions which do not reach the drum. Enough has been accomplished with such use on blast furnace skip ropes for the last decade and longer to justify the claims in advantages. This is not only critical service for wire rope in the hazards involved and desirable continuity of skip operations, but imposes the most severe conditions in abrasion, shock, atmospheric elements, dust,

steam vapors, sulphurous fumes and other factors. Evidence is presented of many blast furnaces where the life of the rope has been doubled or more, and the service of the rope extended to the full campaign of the furnace which is usually four to five years. Applications of these lubricants are made from weekly to monthly or longer intervals, depending on the size of furnace, operational frequency of the skip and other conditions pertinent to the particular location. Ropes have been removed after five years of service, which from all appearances by inspection, could have been used for another year or more.

With the wire rope manufacturers use of improved type lubricants, with the utmost in initial lubrication and the best possible protection against corrosion in shipment and storage, the requirement is for a compatible and almost identical lubricant for operational service. This has developed the necessity for use of the solvent cut-back lubricants, with base material compounding for extremely high film strength, unusual adhesiveness, water repellence, low temperatures to –40 F without cracking or peeling, a semi-hardening film to resist dust contamination, a negative corrosion factor, resistance to salt water and ease of removal with common solvents. These products are purely petroleum leaded compounds, stable in nature and easily applied by pouring, swabbing or spraying. Heating is not required, but storage should be in a heated building as the drop points cannot be much less than 50 F.

Wire against adjacent wire in a rope should, by theory, be line or point contact. Actually the bearing points or lines of the wires are deformed to some extent to support the load. Authorities agree that the loads are tremendously high, and with sliding or moving action by movement of the rope, the protection against friction must be with a lubricant which has a film strength beyond the normal extreme pressure characteristics, which is 20,000 psi or 33 pounds lever arm load minimum by Timken testing machine.

For leaded compounds, the practice in testing is more universal in the use of the Timken testing machine and is probably better known in design and use than others. For routine testing of fluids or plastic lubricants, the lubricant being tested is constantly circulated, and the test conducted for a period of ten minutes. This test establishes results of value for circulating oil systems or automatic and other greasing systems where the lubricant is either constantly or frequently replaced with additional quantities. In wire rope lubrication, such conditions do not exist, as the lubricant film applied must serve for an indefinite period of time. This may be days, weeks or months, depending on conditions of the particular rope installation. The more enduring the film, the more it will qualify the lubricant for infrequent and irregular applications.

In use and widely accepted is the 4 gram test by Timken testing machine. This is known to be the most exacting and severe test that can be made to a lubricant. This test consists of using 4 grams only of the lubricant to be tested, which amount is just enough to cover the periphery of the cup or race and one surface of the block. The machine is brought up to speed and the desired weights added to the lever arm with no addition of the lubricant for the duration of the test. Most high grade lubricants fail within five minutes, some run ten minutes and a few as long as twenty minutes with 43 pounds on the lever arm. The consistent and constant results in tests of lead compounded solvent cut-back lubricants with base material compounding for extremely high film strength is a duration of thirty minutes minimum with 43 pounds lever arm load. This favorably compares to 50,000 psi by the regular or standard Timken machine test with continuous circulation of the lubricant under test.

Summarizing, a necessity exists for the utmost in protection against corrosion of wire rope and the maximum in lubrication protection against wear from the various factors to be encountered. The logical lubricant must have all the desirable characteristics which have been described with emphasis on extremely high film strength and maximum enduring qualities of the lubricant film. Actual service is the only method which can prove the advantages to be gained, however, the Timken 4 gram test can be established as a criterion for guidance in practice of the best possible lubrication of wire rope in the most severe and exacting services.

There is a demand for copies of the following Yearly Proceedings:

1937
1940
1941
1942
1943
1944

If your copies are not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Lighting of

STEEL MILL BUILDINGS

By DAVIS H. TUCK
Chief Electrical Engineer
Holophane Co.
New York, N. Y.

DAVIS H. TUCK

. . . . lighting efficiency has increased eight-fold in the last forty years . . . .

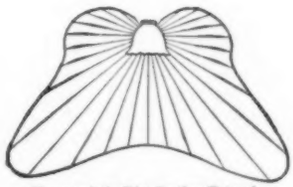
▲ WHILE recently looking through some old lighting literature, the writer came across Vol. 3, No. 2 of "Holophane Illumination," June 1909. The first article was entitled "Holophane Glass in a Steel Mill." The mill was the Cumberland (Md.) Steel Co. and the description shows that this mill 266 × 84 ft had five rows, each of eleven 250-watt tungsten lamps with extensive Holophane reflectors hung 12 ft 6 in. above the floor. Figure 1 shows the reflector used and its distribution curve and Figure 2 shows the 250-watt tungsten lamp used. The illumination was uniform at 2.5 footcandles. The 250-watt tungsten lamp was rated at 2168 lumens or 8.7 lumens per watt. The present 1951, 150-watt lamp is rated at 2600 lumens or 17.3 lumens per watt. Simple calculations show that in 1909 the most efficient lamps and reflectors available gave 4 footcandles per watt per square foot. With modern 1951 practice in steel mills it is possible to get 16 footcandles per watt per square foot with 1000-watt incandescent lamps and 30 footcandles per watt per square foot with 1000-watt mercury lamps with mounting heights of 40 ft instead of the 12 ft 6 in. mounting height in 1909. Thus in 32 years the art in lighting steel mills has progressed by a net gain of about eight times in efficiency. This eight times gain in footcandles per watt per square foot is a result of improved light sources, improved reflector efficiency and improved lighting engineering techniques.

There have been several recent improvements in light sources suitable for steel mill use.

The 400-watt A-H1 mercury lamp rated at 15,000 lumens (38 lumens per watt) has been in use for some time. An improved type is the 400-watt E-H1 mercury lamp rated at 20,000 lumens (50 lumens per watt). The arc tube is made of quartz and the arc length is only 2⅜ in. as compared with 6 in. for the A-H1 lamp. The

Figure 1 — Illustration shows a typical reflector and its distribution curve used in 1909.

Extensive Type Xtraficiency Reflector



Characteristic Distribution Extensive Type Reflector

Figure 2 — Typical 250-watt tungsten lamp used in 1909.

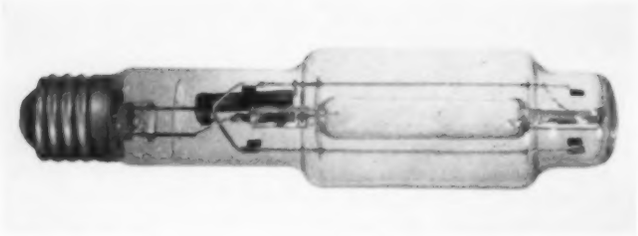


Figure 3 — The 400-watt E-H 1 mercury lamp has a short arc length.

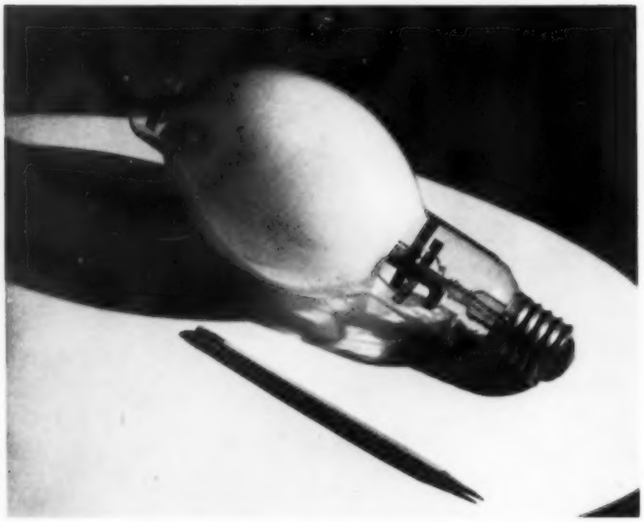


Figure 4 — The J-H 1 mercury lamp has its color value improved because of the addition of a fluorescent phosphor which adds some red to the light.

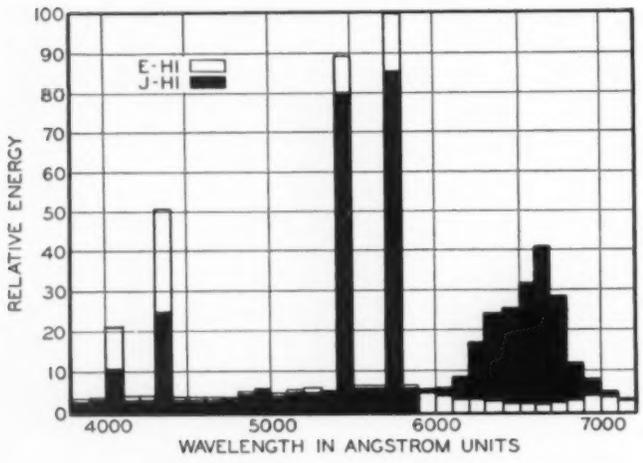


Figure 5 — Spectral distribution of 400-watt J-H 1 lamp.

Figure 6 — A 1000-watt A-H 12 mercury lamp.

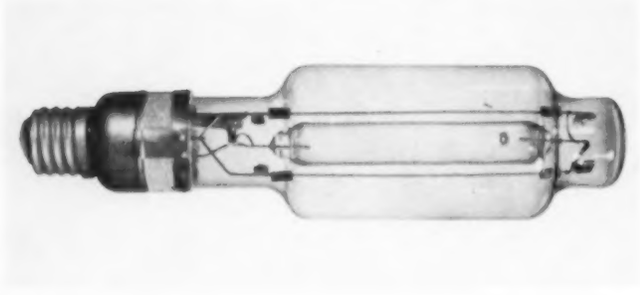


Figure 7 — A recent development in lamps is a 750-watt R-52 silvered neck lamp.

starting time is only 4 minutes as compared with 7 minutes for the A-H1 lamp. The life is 5000 hours. This new mercury lamp, (Figure 3) due to its short arc length lends itself to excellent control when used with high bay reflectors as well as with outdoor floodlights and refractor type outdoor equipment.

The new 400-watt J-H1 mercury lamp has the inside of the outer glass envelope coated with a fluorescent phosphor that adds some red to the light so that the color value of the mercury lamp is much improved. The lamp is rated at 19,000 lumens (48.5 lumens per watt) and has a life of 5000 hours. See Figures 4 and 5. The

Figure 8 — Distribution curve of 750-watt R-52 incandescent lamp.

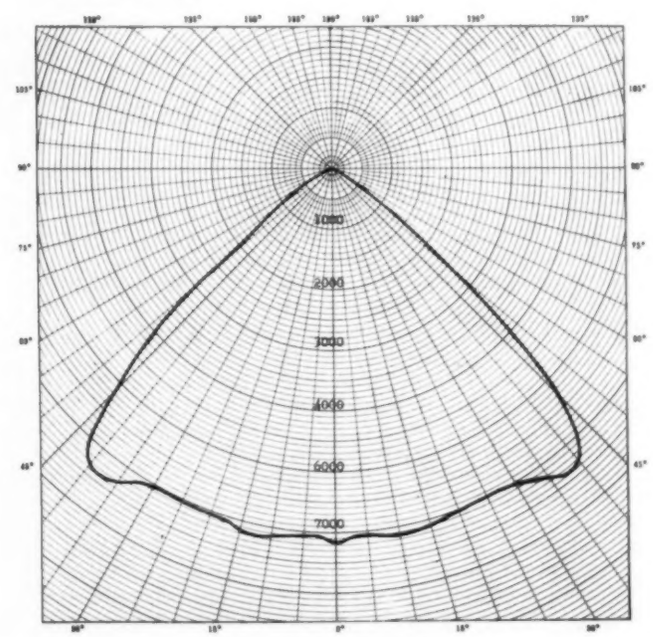
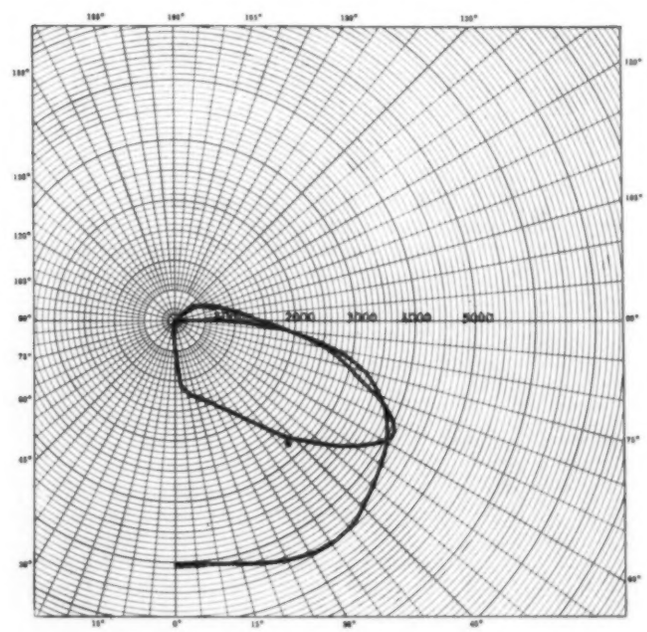


Figure 9 — This new large wide spread outdoor floor light is wall mounted.

mechanical construction of the lamp is similar to the E-H1 lamp. Both the A-H1, E-H1 and J-H1 use the same transformer. This new J-H1 mercury lamp gives excellent 0-60 degree zone output in both the high bay and low bay type of reflectors and will produce about 30 per cent more footcandles in a high bay type reflector and 10 per cent more footcandles in a low bay type of reflector as compared with the 400-watt A-H1 type mercury lamp.

This J-H1 type lamp should be especially useful in

Figure 10 — Distribution curve for light shown in Figure 9.



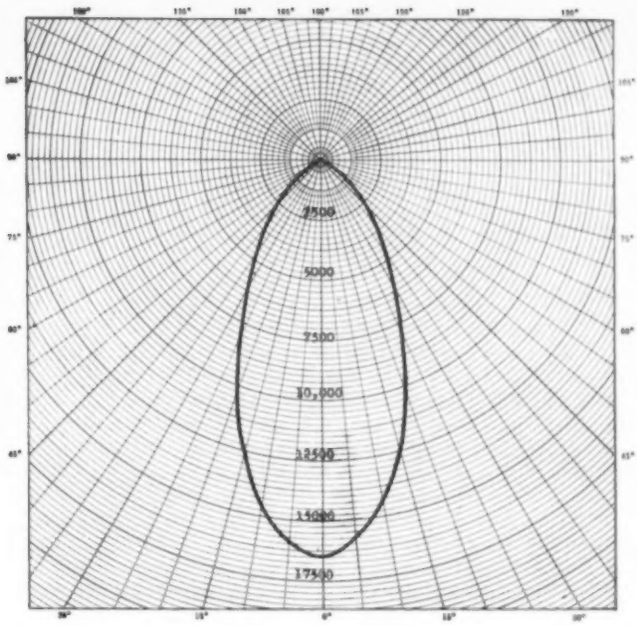
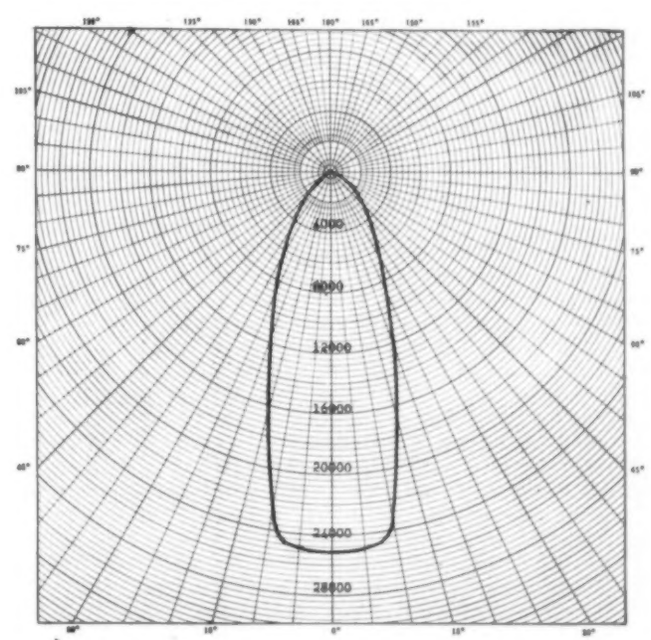


Figure 11 — Distribution curve of high bay unit with J-H 1 400-watt fluorescent mercury lamp.

low bay lighting, such as tin plate inspection, not only because of its good color value, but also because its brightness is considerably reduced because of the larger area of the light source.

The new 1000-watt A-H12 mercury lamp (Figure 6) gives 60,000 lumens (60 lumens per watt). It has a 5 in. quartz arc tube and an overall length of 9 in. as compared with 7¾ in. for the 400-watt A-H1 lamp. It has a life of 3000 hours. It gives excellent 0-60 degree zonal efficiency in high bay type reflectors when these reflectors are designed for light center length of 9 in. as compared to 7¾ in. for the 400 watt A-H1 lamp. These lamps have a use in locations such as chipping or scarfing docks where a high level of illumination (50 footcandles) is required.

Figure 12 — Distribution curve of high bay unit with E-H 1 400-watt fluorescent mercury lamp.



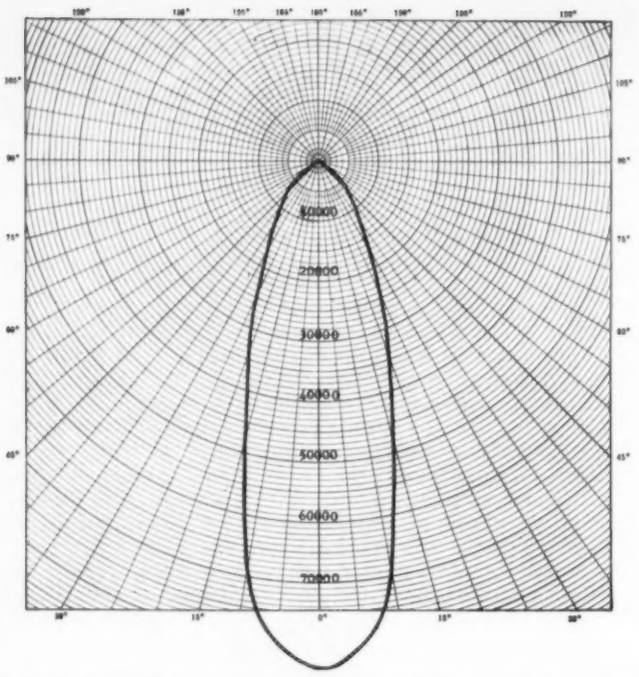


Figure 13 — Distribution curve of high bay reflector with 1000-watt A-H 12 mercury lamp.

A new 750-watt R-52 silvered neck reflector lamp (Figure 7) with nominal rating of 15,500 lumens has been released in 1950. The photometric curve (Figure 8) shown here is taken through four different planes which is not an efficient curve for high bay use.

In lighting equipment there have also been several new developments.

A new wall mounted flood light (Figure 9) for the 400-watt E-H1 mercury lamp or the 500, 750, 1000-watt incandescent lamps give a wide (180 degree) lateral light distribution and the vertical light distribution which is set for a nominal 65 degrees above vertical maximum candlepower is adjustable between 55 and 75 degrees. See Figure 10. This new unit has application

Figure 14 — This incandescent vapor tight unit is of entirely new construction.

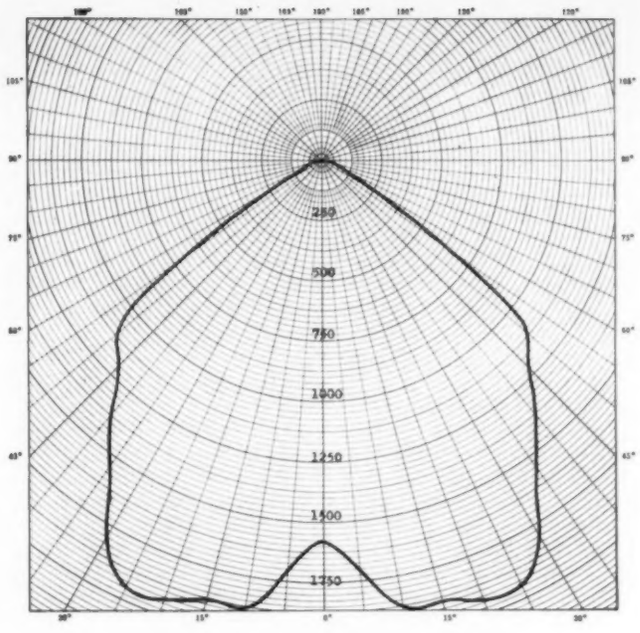


Figure 15 — Distribution curve of new vapor tight-dust tight unit for 200-300-watt incandescent lamps.

for outdoor craneways, loading docks, ore docks, parking lots, roadway lighting between buildings, blast furnace lighting and similar outdoor locations. The unit is weather-proof.

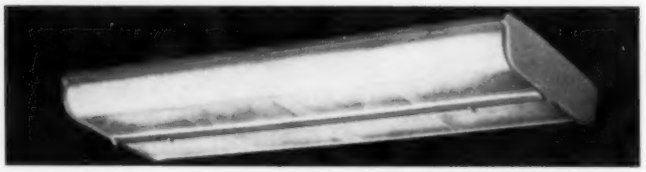
A new high bay unit has been made to utilize the 400-watt J-H1 fluorescent mercury lamp. The light output is excellent being 73 per cent in the 0-60 degree zone (Figure 11) as compared with a similar reflector for the 400-watt A-H1 mercury lamp of 68 per cent.

A new high bay unit is now available for the new 400-watt E-H1 mercury lamp. The exceptionally high 0.60 degree output of 80 per cent is an indication of the efficiency of this lamp reflector combination. See Figure 12.

A high bay unit for the 1000-watt A-H12 was exhibited for the first time at the 1950 Association of Iron and Steel Engineers Convention in Cleveland. In addition to the high efficiency of the 1000-watt A-H12 mercury lamp the reflector also has an extremely high 0-60 degree output of 78 per cent shown in Figure 13.

A new 200-300-watt vapor tight unit of entirely new construction was made available late in 1950. This is shown in Figure 14. This unit is not of the usual threaded glass globe construction but instead has a metal to metal gasketed joint. It is made of heat resisting glass so that it can be used out of doors as well as indoors. The efficiency is phenomenal for an enclosed unit, being 69 per cent in the 0-60 degree zone,

Figure 16 — The surface attached fluorescent unit is used with four slimline or starter type lamps with brightness control along and across axis of lamps.



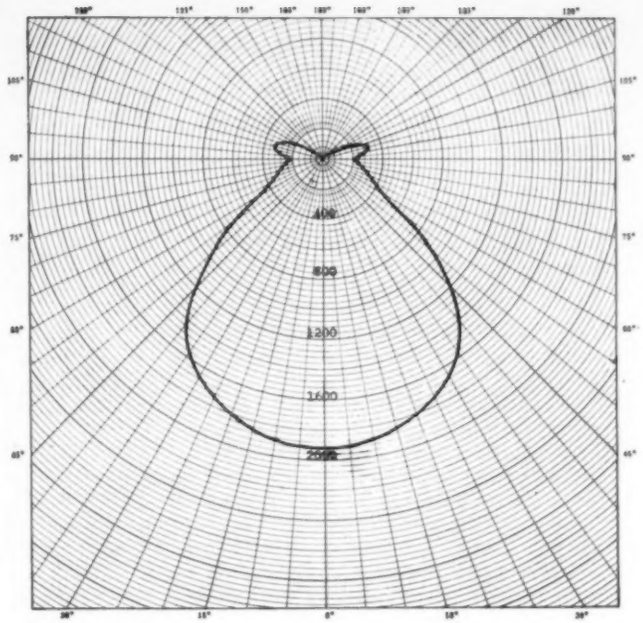


Figure 17 — Distribution curve for unit shown in Figure 16

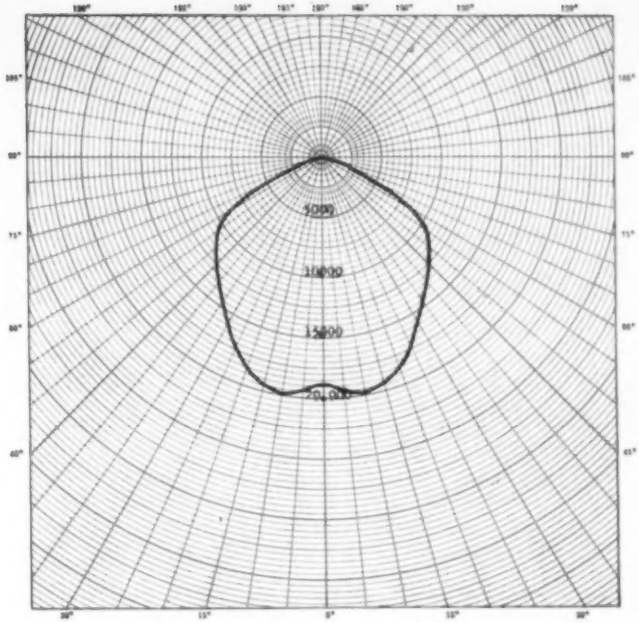


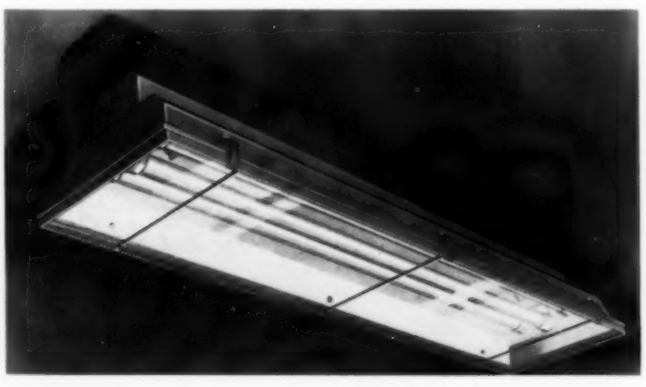
Figure 19 — Distribution curve for triple porcelain enamel high bay unit with three 1000-watt incandescent lamps.

or better than the usual nonvapor-tight units of the open type. See Figure 15. This new vapor tight unit has application in low bay lighting when vapor tight equipment is required. It is also listed by the Underwriters Laboratories as Dust Tight, Class II, Groups E, F, G.

For office lighting a new surface attached 2 or 4 lamp fluorescent unit was announced late in 1950. The unit utilizes 4 ft starter type fluorescent lamps or 4 or 8 ft slimline instant start lamps (Figures 16 and 17). It uses low brightness lenses with brightness control both across and along the axis of the lamps. It gives an upward component of light to the ceiling and has a high utilization coefficient of 25 footcandles per watt per square foot under favorable room conditions. The lenses are hinged for easy maintenance and the depth is extremely shallow being only 4½ in. deep. It is particularly adapted for steel mill office lighting because its tight enclosed construction should make the dirt and dust depreciation minimum.

New vapor tight units for the T-12-48-in. slimline lamps have been announced early in 1951 (Figure 18). These have heat resisting plain glass or prismatic lenses enclosing the bottom opening. Twin and triple high bay units for mercury and incandescent lamps have recently been made available. Typical of these is a triplet made up of three porcelain enamel reflectors whose distribution curve is shown in Figure 19.

Figure 18 — A vapor tight fluorescent fixture.



DISCUSSION

PRESENTED BY

WILLIAM S. JOHNSON, Plant Industrial Hygienist, Bethlehem Steel Co., Bethlehem, Pa.

H. H. ANGEL, Electrical Engineer, Bethlehem Steel Co., Bethlehem, Pa.

E. H. POWELL, General Electric Co., Trenton, N. J.

DAVIS H. TUCK, Chief Electrical Engineer, Holophane Co., New York, N. Y.

Wm. S. Johnson: I would like to refer to the Illuminating Engineering Society and their code for industrial lighting. Would you care to comment on how fair you think it is to industry? My opinion is it is written a little bit on the "up" side. I think it should be down-graded a bit.

H. H. Angel: I would like to ask Mr. Tuck several questions in reference to lighting. The first is in reference to fluorescent lighting. One of the large electrical manufacturers has been advocating the use of 277-v lights on systems where a power circuit of 3-phase, 4 wire, 480-v is employed, the voltage of each phase to ground being 277 v. I would like to know how much this has been in use and how he considers this voltage to ground for a lighting circuit from a safety standpoint.

The second question is in reference to steel mill lights without reflectors. I am thinking of lights in the neigh-

borhood of 500 to 750 watts, which might be installed overhead in place of standard incandescent lights with fixtures. I believe one of these lights is the Birdseye type. What is your opinion?

The third question, which is one I may have asked him when I saw him at the AISE convention in Cleveland last fall, is in reference to mercury vapor lamp installations. Where these are installed in a mill, it is also necessary to use a certain number of incandescent lamps, because Mr. Tuck explained that if a dip in voltage of power failure occurs, you will not have any light from the mercury vapor source until 6 or 7 minutes after the restoration of power. I have seen many installations where you may have two rows of mercury vapor lights and one of incandescent, or rows with alternate types, and also some with twin units, consisting of a mercury vapor light alongside of an incandescent type. I would like to know if the twin unit is used extensively?

E. H. Powell: Another comment to Mr. Tuck — when he was telling of the cost of mercury lamps from the lighting standpoint, he showed that you get twelve times the lumen output, but that they cost twelve times as much as a 1000-watt lamp. I think it is more in the order of five times for the cost of the mercury lamps as compared to the incandescent. I did not want you to scare the men off on the use of mercury lamps.

Davis H. Tuck: Mr. Johnson asked the first question, about the new Industrial Lighting Code. That is the one sponsored by the Illuminating Engineering Society and adopted by the American Standards Committee. Your question was "Did they not set the footcandles a little high?" Here is the joker in this code. Engineers, in general, use a factor of safety in lighting of 0.7. Steel mill engineers are a little bit more practical than other consulting engineers; they generally use a safety factor of 0.6. This actual safety factor in the average steel mill is 0.45, or less. So the Industrial Code, in raising the footcandles higher than they should be in service is on the right side, as long as these fictitious factors of safety figures are used. If you will just think for the moment what makes up a factor of safety in lighting: You multiply everything you do on engineering by something to take care of unexpected factors.One is dust, and dirt on the lamp and reflector. In the steel mill we know it is pretty bad — it is at least 0.7, by itself. Then comes along the lamp depreciation. Lamps do not last forever. They go down gradually, too, so probably around 0.9 or something around there would be about right. Now, 0.7×0.9 is 0.63. Then there is an item called interception that people do not like to look at. If you will notice when anybody goes around checking the footcandles, everybody gets out of the way so that they do not cast shadows on the paddle. In working at the drafting board or anywhere else, you will cast a shadow. The building columns cast a shadow; products cast a shadow — there are all sorts of interceptions, and they run higher than you may think. Call it 0.6 — it is probably 0.5, but it is high.

Then there is voltage drop. We just blandly forget about it. We do a good job in the plant for 2 per cent, and a lot of them get a lot worse than 2 per cent voltage drop, and unfortunately, in lighting, 2 per cent in voltage drop does not mean 2 per cent in lighting. It means about 6 per cent, depending on the kind of lamp you are going to use. So you have another depreciation there. And if you multiply all the things together, they come to about 0.45.

So, although the values given in the new code may seem high, I think they are safe values to calculate on because there are many other things too, that come into the picture.

Take the distribution curves we showed you. That is the way to calculate illumination. All the methods are made up from a distribution curve. That is one thing they use. That distribution curve is made in the laboratory. It is made on the best piece of equipment the company can turn out, because they want to make it look good. You do not get that stuff when you buy it. You get something less than that. You may get something as good, but I doubt it, it is like the cars you get — you get a bad one once in a while. None of them are as good as the ones they run the mileage tests on. And a lot of other things happen in the course of calculation so that the recommendations on paper does not mean so much in actual practice. For instance, in an office, which is a clean place, relatively, if you want 50 footcandles in service from a fluorescent job, which is about right, I think you have to calculate for about 75 or 80 or 90 or thereabouts on paper to get 50 in service.

In the steel mill it is a lot worse than that. So I do not feel too bad about the code asking for higher footcandles than we are accustomed to being asked for.

I picked up something here the other day showing the footcandles back in 1909 — in schools, offices, and so on. In an operating room in a hospital they asked for 10. Today we give a thousand, at least. So you see, as lights get cheaper, up goes the footcandles required.

One question was about the fluorescent on 3-phase four wire with 277 volts between one side and ground. That is nothing new. It was used during World War II for lighting some of the airplane plants. A special ballast was made for that circuit and they used a few of them — not a great many. There was a big airplane plant that had a big installation of them, and just about the time they got the thing going the war closed, and nothing has been done on it since, as far as I know. I do not think the ballasts are available. There is no reason they can not be used. I do not think the voltage amounts to much; it is way up out of the way, anyway. I know one plant ran high voltage for controlling the lamps with contactors and remote control switches. It did not bother them much. I do not think it would be anything that would be a hazard, especially if you watched your neutral and had the live side on the right not the wrong side, so if anybody went to change a light they did not handle the undergrounded side and get a jolt.

The next question was from Mr. Angel, about the 500 and 750-watt reflector lights. He mentioned particularly the Birdseye. The reason those lamps are used — and there are a lot of them used — is because it absolutely does away with all maintenance. Nobody has to clean the lamp or the reflector. When the lamp gives out you buy a new one. But you pay.

There is such a thing as an economic analysis, made up of two parts, Part one is first cost including the ballast, wire, and so on, cat-walk or whatever you have for maintenance and the cost of initial lamping. You have to pay for the lamps.

Operating cost is the second part — taking in the cost of current, cost of relamping, cleaning, replacing lamps after they burn out (you have got to buy new ones). That is an operating cost.

Now, if the operating cost under one system is less than it is on another system, and if the first cost is greater under the one than the other, there is a balance, and you have to weigh it. If you can save enough in operating cost to pay for the increased first cost in two years, I would say it was a pretty good investment. People do not look much past two years, today. It used to be we figured for five or ten years — but who knows what is going to happen now?

So you can show these reflector lamps are not economically sound and not sound for two main reasons — one, they cost a lot of money, and two, the distribution of them is not correct for high bay lighting. Make your own analysis. You can not make an analysis of that sort in a general way — you have to take a specific job — a mill, so wide, so long, so many square feet, so many hours burning a year, so many kw hours of load and so forth, and work it out for the particular job. It may not work out the same for the other job because the factors controlling the costs are different for every job.

As to the twin as against single units for high bay lighting, some using mercury, some using incandescent, there is a good reason why twins are the most economical lighting systems to use. The reason is this: steel mills are becoming higher and higher from the bottom of the girders or crane clearance to the floor. Steel mills of 40 feet are commonplace, today. They are higher than that in a lot of them. In any high bay unit, the ratio of spacing and mounting height is 1:1, which means that you can space your units 40 ft apart and get uniform illumination. Now 40 × 40 is 1600 sq ft for one unit to cover, and with a 1000-watt lamp you do not get much light with 1600 sq ft coverage. So, next, you space the lights in closer so you can get more watts per sq ft on the floor. By using the twin unit, you can keep the maximum spacing and still get the maximum illumination. You can therefore save wiring by having less connections, you will have less maintenance, less cleaning and it reflects economy all the way through the line, to double up or triple up, whatever may be necessary in order to get the footcandles required.

There was one more question about mill painting. Contrary to general opinion, painting a room a light color does not increase the illumination very much. If you do not believe that, pick up your lamp book on utilization factors and look up the difference between dark walls and dark ceiling and light walls and light ceiling — you will find the difference is so insignificant it is not worth talking about. What the painting does do, however, is to make a room look cheerful and bright, it makes for better housekeeping, it makes for more cheerful workers. That is the real reason for it.

I was reading a book recently on industrial lighting and I came across two subjects relating to drafting rooms and offices. I picked on drafting rooms first because in the drafting room, there is where creative work is done — they are not productive workers, the draftsmen. I do not think a draftsman is working a great percentage of his time — but he is mulling things over and thinking over things so that he does not have to put things down on paper and then rub them out later. It is creative work. So I jotted down the things to help a draftsman for accuracy and speed, lack of mistakes, and so on. I have "air-conditioning," which means cooling in the summer and heating in the winter; "acoustical treatment" in the room, to cut out the noise, or cut down the noise level, and "good lighting." I have added to that one other thing — that was "decoration," which comes back to painting. You get the walls and ceiling and floor and desk tops of the right reflection factor to make the room right from a comfort standpoint.

Heating of STEEL MILL BUILDINGS

By GEORGE J. CAMPBELL
Assistant Fuel Engineer
Bethlehem Steel Co.
Sparrows Point, Md.

. . . . sound engineering is required to adequately and economically heat mill buildings . . . .

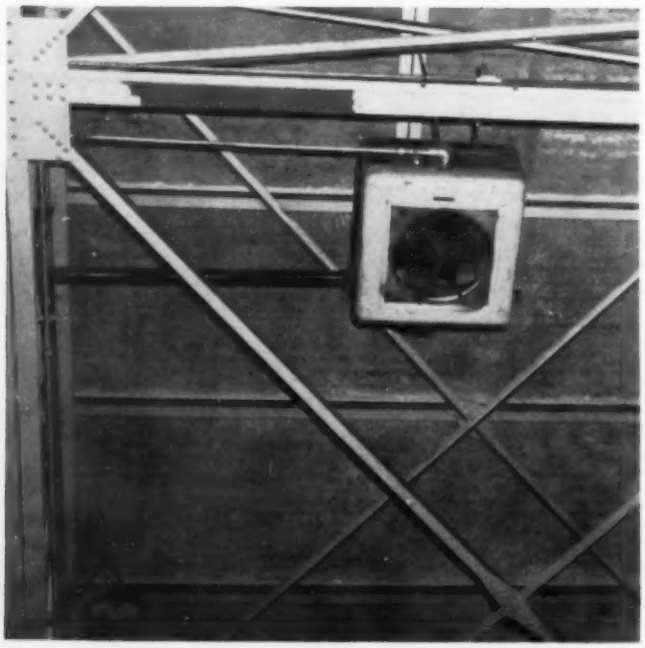
▲ IN simplest terms, heating involves maintaining a comfortable temperature inside a working space. Room temperature and body comfort are usually considered to be closely associated. However, this is not entirely true, as humidity, air currents, cold or hot walls, etc., also affect body comfort.

Under normal mill working conditions the body produces and gives up about 800 Btu per hour, dis-

Figure 1 — Gas-fired unit heaters are used in the sheet steel warehouse.

Figure 2 — Direct gas-fired unit heaters are also used in the cold mill building.

Figure 3 — Illustration shows method of mounting vertical down-blow steam unit heaters.



tributed approximately as follows:

380 Btu by radiation.
220 Btu by conduction and convection.
120 Btu by evaporation.
80 Btu exhaled by lungs and other body waste.

If the total loss is more than 800 Btu per hour, the body becomes cold, and if the loss is less than 800 Btu per hour the body will feel warm. Comfort depends on maintaining equilibrium between loss and gain, and also a reasonable balance of the individual losses.

For example, in a large building with a room temperature of 72 F, where men are working about 10 feet from a corrugated steel wall with an exterior temperature of 30 F, the body will give up heat by radiation to the wall, well in excess of the 380 Btu normally lost, so the men will be cold. The logical solution in this case would be to increase the room temperature in their vicinity so they would have an excessive heat gain by conduction convection. The same results can be accomplished more economically by placing a temporary heat shield between the men and the cold wall, thus eliminating the body heat loss by radiation.

Another example would be the case of men in the path of an air current from a blower-type heater. These men will be either too hot or too cold, and, of course, uncomfortable because there is a continual unbalance of body heat loss by conduction, convection, and evaporation.

Cold floors absorb heat from feet and legs, causing another case of body heat unbalance and discomfort. The cure is not more heat in the room but an insulated warm floor.

It is well to keep in mind that a detailed analysis of factors affecting comfort, as well as temperature, should be incorporated in the attack of any heating problem.

BUILDING DESIGN AND HEATING

More thought should be given to the heating problem in designing new steel plant buildings. In general, additions to a plant usually follow the building pattern which has been in effect for years, and old buildings frequently present many shortcomings from a heating standpoint.

The demand for comfortable working conditions, both in summer and winter, is becoming more pressing every year. Well heated, ventilated and lighted buildings will pay dividends in increased morale and efficiency. In some present-day structures it is difficult to arrive at an economical, satisfactory, and efficient heating system. A new approach to mill building design should therefore be in order.

Particular attention should be given to protective metal siding. Joints, eaves, flashing, and window sash could be much tighter. Ventilators and monitors should be equipped with tight closing dampers. Steel sliding doors, shipping doors, etc., should fit snugly and move easily. Shipping docks should be arranged so their outside openings do not cool the whole mill.

The two major causes of heat loss in a building are: (1) sidings and roof; (2) infiltration because of poor joints, cracks, loose fitting doors and windows, etc. Correction of these two factors with the resultant savings in heating cost must be balanced against the cost of the improved structure. As pointed out earlier,

a new approach to building design may be in order, from a heating standpoint, and this approach should originate with and be recognized by our building design engineers.

VENTILATION AND HUMIDITY

Excessive infiltration will cause cold, drafty areas in a building. There are two methods of approach to this problem: (1) repair or plug up the leaks; (2) draw in new fresh air through a heater slightly in excess of the amount which would come in by infiltration. Either method may prove expensive and a compromise solution is usually most satisfactory; closing up as many leaks as practical and keeping the building under a slight positive pressure.

For normal ventilating requirements, the amount of infiltrated air will probably be sufficient without forced additions. In pickling, galvanizing, tin plating and fusion lines, continuous hot strip mills, foundries, etc., a greater number of air changes per hour are required than can be accomplished by infiltration alone. Such buildings can be designed with monitors at the roof and louvers at the bottom for ventilation by natural draft. This will be satisfactory in the summer, but under winter conditions, a combination of natural draft and heated forced ventilation should be used. Whenever possible all air pollution sources should be controlled by local exhaust ventilation, rather than by means of general ventilation.

In some cases the moisture content of the heated air should be given special consideration. For example, in a mold loft or pattern shop, the humidity should be on the high side, to prevent shrinkage or drying of material; in a bright sheet-steel storage or handling space the dew point must always be low enough to prevent "sweating" of steel and subsequent rusting.

INSTALLATION AND APPLICATION

There is no hard and fast rule by which we can say that a definite type of heater should be installed in a specific type of building. Each job must be considered on its own merits; first, the type of fuel available, whether steam, gas, oil or coal; secondly, the shape, size and type of building; third, the degree of comfort desired, ventilation, etc., and fourth, ultimate cost.

In general, it is desirable to circulate large volumes of low-temperature air, as this tends to reduce stratification and gives more uniform temperature. Heaters should not be placed where they will use up valuable floor space, blow at permanent obstacles such as machinery, blow on men at work, or interfere with natural light.

In the examples which follow, a number of heater applications are covered. They give a fairly good cross-section in the application of heating to steel-mill buildings. These applications meet our individual need, and they do not necessarily constitute the only method of heating or the only type of heating equipment that could have been used.

In our coil storage space, steam vertical blow-down heaters are used. The principle need of heat in this building is to keep the dew point high enough to prevent sweating of the steel, with the resultant rust condition.

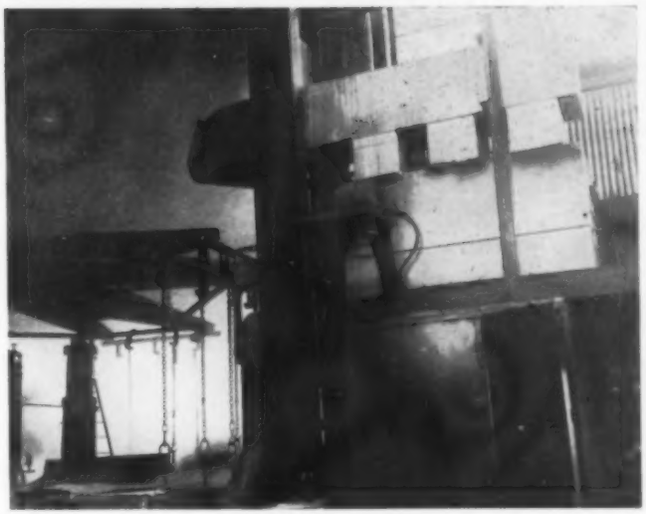


Figure 4 — The steam unit heater is effective in clearing away fumes from batch type picklers.

Figure 1 shows a galvanized sheet-steel warehouse with a gas-fired unit heater. This building was originally heated with five gas-fired centralized heating plants, with the necessary duct system and outlets along the walls and crane columns. Due to an expansion program, two of the central stations were removed, and because no space was available for their relocation, a number of individual units were installed.

Figure 2 shows a cold mill building looking north, showing the installation of direct gas-fired unit heaters. Extensions to this building are now underway, and eventually it will be 1620 feet long by 105 feet wide and heated by eleven 2,500,000 Btu heaters. The distance from the floor to the bottom of the roof truss is 55 feet.

The hot-strip processing building has an arrangement of vertical down-blow steam unit heaters. This is actually two adjacent buildings — one 1300 ft long and 106 ft wide, the other 700 ft long and 90 ft wide. There are 30 heaters in the two buildings. The main steam header, regulating valves, traps, etc., are located along a walkway, in the high bay at the truss line (42 ft above floor). Figure 3 shows a close up of one of the heaters.

Figure 5 — A central heating system is used in the tin plate sorting room.

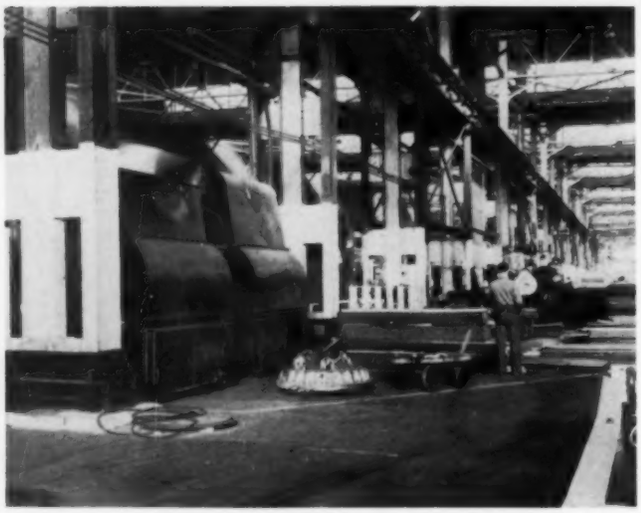


Figure 6 — Bunker C fuel oil fired heaters may require a good ventilating system to carry away the fumes.

Figure 4 shows a steam unit heater with duct work. This heater is used to clear away steam and acid fumes from a batch-type pickler. In our tin plate warehouse, we use gas direct fired unit heaters.

Tin plate sorting room shown in Figure 5 has a central system with ducts along the walls for distribution. There are three central stations in this building, and while the heater rooms take up considerable floor space, this type heating is best for this application. It is questionable whether you would be able to keep women and girls working with a vertical heater or a unit heater of any type which blows warm air directly on them.

The carpenter shop has small down-blow steam unit heaters.

The hot strip mill processing buildings have seventeen bunker "C" fuel oil-fired heaters, two of which are shown in Figure 6. There are two adjoining buildings and the heaters are placed in pairs along the central building and crane columns. The buildings are about 1075 ft long and 90 ft wide. The distance from the floor to the roof truss is 40 ft. The heaters are direct-fired with the flue products mingling with the heated air and also circulated.

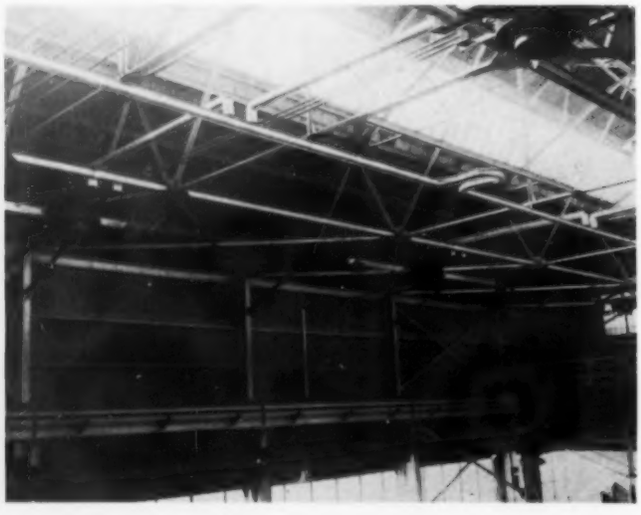
Blow-down type heaters are also used in the roll shop. The view of Figure 7 was taken above the crane to show the method of mounting. These heaters were installed in 1941. The building is 260 ft long and 55 ft wide, and the heaters are mounted 42 ft above the floor.

Bunker "C" fuel oil-fired space heater with ducts for distribution are used in the wire mill as well as horizontal-type steam unit heaters in wire mill straight cut department.

Gas-fired unit heater shown in Figure 8 is used in wire mill bethanizing department. This heater is installed principally to control dew point in the building, in order to prevent condensation on trollies, and conductors to the plating tanks, and other electrical equipment.

Figure 9 shows a horizontal-type steam unit heater, inverted and suspended. Adequate floor space was not available at suitable locations for proper heat distribution. This building is a machine shop, it is 525 ft long and 180 ft wide. The middle or main section is 80 ft wide and 72 ft high, there are two 50-ft lean-to's × 58 ft high on both sides of it. One section has a mezzanine floor at the 22 ft elevation.

Figure 7 — Illustration shows method of mounting two blow-down type heaters.



CONTROL

The rate of heat losses in buildings changes continually from hour to hour and day to day during the heating season. Too little heat means discomfort, too much heat means excessive cost. In the planning of any heating system, temperature control is of major importance and very often the success of the whole system depends on the method and proper functioning of room temperature control.

Costwise this is particularly true in view of the present day high fuel cost. Wherever practical it will pay to automatically control room temperature.

SAFETY

Safety of installation and operation of heaters should not be overlooked. When installing heaters they should be accessible for maintenance and when not accessible necessary ladders, platforms, etc., should be provided. Protective guards are usually necessary around the heater, pipe work, regulating valves, and electrical equipment; stacks and steam pipes are insulated.

Every possible precaution should be taken to prevent explosions in combustion chambers of direct-fired heaters; safety devices should be checked frequently, operating procedure reviewed at intervals with heater attendants, and control panels should be locked to prevent unauthorized persons from tampering with relays, timers, etc.

With copper tube and fin-type steam unit heaters, fans, motors, etc., may work loose. When evidence of loose parts become apparent because of vibration or noise, the heater should be shut down and repaired. Blow-down type heaters should have a guard over the fan outlet, and if it is the type where a fan blade could fly out of the top, the top also should be guarded. I know of several cases of broken fan blades, fortunately no one was injured when they fell to the floor.

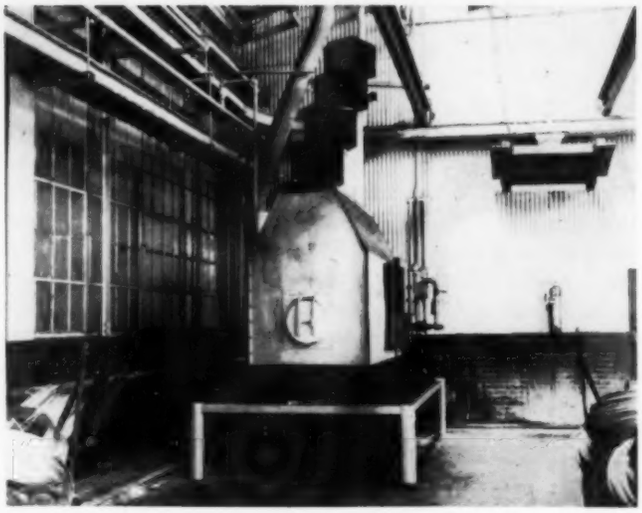


Figure 8 — This gas-fired unit heater is used primarily to control dew point and condensation.

MAINTENANCE

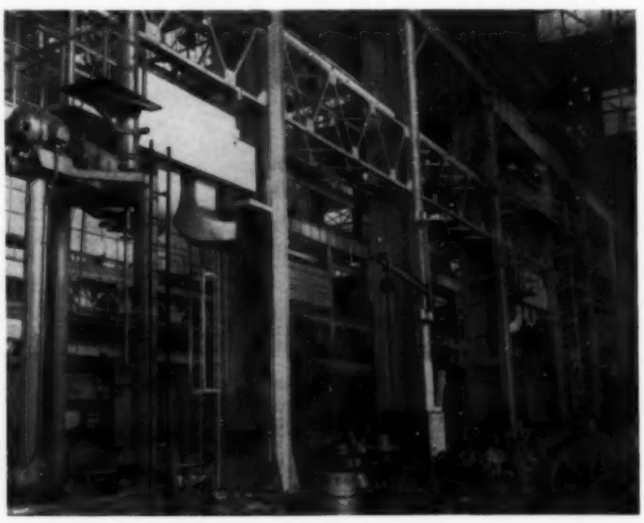
Heating systems are usually quite simple and until an actual breakdown of some part of the system develops, they do not always receive the inspection and maintenance they require for efficient operation.

It is possible to build up a gradual and progressive series of faults which would not shut the unit down but will greatly affect the over-all efficiency.

In the case of direct-fired space heaters, the whole unit should be completely cleaned at least twice a year. This cleaning should include the combustion and air chambers, flues, stacks, fans, and blowers. The burner equipment should be over-hauled and cleaned, and the electrical system, including thermostats, pressuretrols, draft controls and safety devices checked.

In the case of copper tube and fin-type steam unit heaters, dust and dirt accumulation must be cleaned from between the fins at least once a year, preferably at the start of the heating season, and the heater case, fan and motor inspected for mechanical failures, steam traps, and strainers over-hauled and cleaned. Water hammering or air lock in copper tube type heaters will cause excessive pressures to be momentarily built up well in excess of the designed pressure limits. This may burst the coils or cause leaks at brazed joints and it probably contributes more to damaged coils than corrosion due to oxygen and carbon dioxide.

Figure 9 — Machine shop is heated by a horizontal type steam unit heater.



DISCUSSION

PRESENTED BY

F. C. SCHOEN, Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

WILLIAM C. SCHULZ, Superintendent Power and Maintenance, Bethlehem Steel Co., Steelton, Pa.

G. O. VAN ARTSDALEN, Maintenance Superintendent, Henry Disston & Sons, Inc., Philadelphia, Pa.

A. J. FISHER, Assistant Chief Engineer of Construction, Bethlehem Steel Co., Bethlehem, Pa.

E. H. POWELL, General Electric Co., Trenton, N. J.

GEORGE J. CAMPBELL, Assistant Fuel Engineer, Bethlehem Steel Co., Sparrows Point, Md.

F. C. Schoen: One point is apparent — there seems to be a rather constant battle between one group trying to heat the buildings and another group trying to ventilate them, but I did not get a solution for the problem — it still seems to be in the stage of a battle.

There was one statement made concerning the radiation from the building as it affects a man's comfort and the radiation of his body heat to the building walls. I am wondering — I believe that was Mr. Campbell's paper — how effective the thing we tried several years ago would be, (or what is his opinion on trying to get a compromise between ventilation, trying to keep the men cool in the summer time, and trying to keep the building closed up in the winter). We installed wooden panels entirely around one of the mill buildings. These are easily removed — opening up the buildings, pulling in plenty of air in the summer and in the winter time you have a tight enclosure. I am curious as to the effect of the wooden construction, instead of the metal, on the quantity of body heat radiation?

Wm. C. Schulz: Do you have any ventilation problem from burning the Bunker C oil, which I understand is getting higher and higher in sulphur content?

G. O. Van Artsdalen: I would like to ask Mr. Campbell, whose paper dealt with heating, to elaborate more on the question of control of the unit heaters, and the possibility of maintaining fairly well-regulated temperatures in the buildings. Are they thermostatically controlled or manually operated? It seems to me that the proper location of the thermostats has a great amount of bearing on the successful and uniform heating of large buildings where numerous unit heaters are employed.

A. J. Fisher: I am thinking of old steam radiators in the long office buildings that are right under large areas of windows. The heat from these radiators goes right up alongside the glass and dissipate heat through

the glass to the outside atmosphere. Overhead steam heaters in these buildings are a great improvement, in many ways. I hope the author will talk a bit about the automatic temperature controls that can be applied to these vertical heaters which can follow the seasonal change in temperature and the daily change in temperature. Also I would like to have him discuss the advantage of blowing the hot air in the top of buildings back down to the floor.

There is another class of heaters which use Bunker C fuel oil. They can be made fairly large as was described, but do not have the advantage of automatic control except by manual efforts and they take quite a bit of manual attention. A moot question is when to put in steam heaters and when to put in oil heaters. It all goes back to heating cost per year, and capital cost. The capital cost of the steam heaters are much cheaper than the capital cost of the unit-fired oil heaters, if you neglect the cost of boilers that go with the steam heaters. The plant condition at the time, or the amount of steam generating capacity available at the two has a lot to do with the decision on what sort of heaters are installed. Now I think the author should discuss this, just which way to go, either to the oil-fired unit heater or the steam heater; how, why, and when.

E. H. Powell: What I am going to say may sound like a "plug," but on this heating problem why could we not use infra-red heat lamps to give off radiant energy? They are using them in homes quite successfully — not on a big scale, to be sure. They are using them for brooding chickens and are competing successfully with other forms of heat such as coal, gas and oil. With heat lamps, you have an excellent control of the source of heat — and in the case of radiant heat you do not have to worry about the room temperature. Your room temperature can be down quite low as was proven again in the case of chickens in a cold storage house, where they were raised very satisfactorily.

George J. Campbell: Mr. Schoen, asked about solid wood paneling on the side of buildings in place of corrugated iron. I believe he meant that in the summer time they take down a section, possibly 10 ft high, of siding around the mill buildings for ventilation purposes and in the winter time when it gets cold and windy they again put the siding in place. This is a common practice. Usually in the type of building where this is done you are not interested in heating the building in winter. We do that in soaking pit mill buildings, where there is no heating of the building other than furnaces. Also in some of the plate mill and blooming mill buildings, however, we use corrugated metal siding. But it is true, if you did use wood instead of steel, a half-inch wood board would give a lot more protection from the transfer of heat from the building as against the steel. The heat transfer rate of plain corrugated steel is 1.50 Btu per sq ft per degree temperature difference, while ½-in. board is 0.77.

Mr. Schulz asked about ventilation from an oil-fired heater. We have heaters burning Bunker C fuel. The ventilators in the building are on the high bays of the building. Quite a bit of ventilation is required in these buildings, probably 6 or 7 changes an hour, which is one reason why we can use Bunker C oil, and although normally it is below one per cent sulphur, the fumes from the burning of the fuel oil are not obnoxious. Occasionally we get some oil that has a higher sulphur content than one per cent. Then it does get objectionable.

Mr. Van Artsdalen asked about controls and regulators. On the overhead type of down-blow heaters we use thermostatic control, sometimes one thermostat for one heater, sometimes they are in groups of three or four heaters for one thermostat; it is an ordinary on and off thermostat stopping and starting the fan on the heater. It does not shut off the steam. We have had quite a bit of success with these, and they maintain fairly uniform room temperature. In general the plant people leave them alone. Sometimes it is best to paint them black, for if you put a shiny new one up, the chances are it will not be there the next day. One of my men one time put a sign on several "Danger, 440 Volts." They left those alone too.

The direct oil-fired heaters are hand controlled and hand operated. We have an operator that takes care of the heaters which are stopped and started according to the heat requirement of the building. Most of the gas-fired unit heaters, the ones up around one million or two million Btu's are automatically controlled. They go through a regular control cycle similar to your gas-fired or oil-fired boilers at home. It starts the blowers and for 30 seconds purges the combustion chamber then ignites the pilot flame automatically. Unless there is a good substantial pilot flame the main gas valve does not open. This system is quite satisfactory and we have been keeping them in automatic operation, in spite of the fact that the gas from the coke ovens contains quite a bit of hydrogen-sulphide, etc.

Member: Do you have a manual re-set or automatic re-set, on these?

George J. Campbell: A manual re-set. We had trouble with a few heaters on which we could not readily analyze the trouble so we put a padlock on the controls and re-set so only an experienced man could re-set and start up heaters after a failure. On other gas unit heaters, and, the self-contained type, the large ones, rated at 5,000,000 to 10,000,000 Btu's, as shown in the warehouse and tin sorting room, the only control is an automatic gas shut-off valve, in case of power, gas or flame failure. They also come under the attention of the attendant who operates the heaters and regulates the amount of heat for the buildings.

Incidentally, in that type of heater, where you have a large combustion chamber and are handling a large volume of air to be heated, there is one particular drawback that it might be well to point out. When the heater attendant needs less heat in the building, he cuts back on the gas flow. That is all right as far as the heat is concerned, except that the gas flow gets down to a point where the flue products are being chilled to such an extent that, quite a bit of condensation takes place inside the combustion chamber and stack and then you have water running out of the heater and stack. This condition is particularly bad on coke oven gas fired heaters, as coke oven gas is high in hydrogen.

A better method of control would be to by-pass some of the recirculated air around the heating chamber so as to keep your flue-product temperature up around 400 F and prevent condensation. Condensation with coke oven gas is particularly bad because of the

hydrogen-sulphide, as a dilute solution of sulphuric acid is formed which attacks all iron parts.

Mr. Fisher requested or suggested that I talk about capital costs on unit gas or oil-fired heaters vs steam heaters. When we have a problem of heating a building — the first thing we tackle — is to find out what kind of fuel we are going to use; whether it be Bunker C fuel, oil or gas, or steam. Now, the first consideration in steam is whether or not it is available and how much it costs to produce. With the coke oven gas the same thing is true. However, if you build up a large use of coke oven gas for unit heaters in the winter you are in effect taking that gas away from some of your metallurgical furnaces, so a plant fuel balance also enters into consideration on the kind of heaters to use. One method of justifying gas is to install both oil and gas firing on several large reheating furnaces, then in the summer you can use surplus gas and as cold weather approaches gradually substitute the gas for fuel oil, and use the gas for space heating.

In the case of Bunker C fuel-oil unit heaters, it is a problem to keep a small amount of oil, usually 5 to 10 gal of oil per hour, burning a small combustion chamber, and one of the things to consider in Bunker C oil unit heater installations is the labor cost of an attendant.

The capital costs study of course would have to take into consideration any power plant additions to steam generating capacity, and there, again, you must evaluate the fact that when you use steam for heating you are in effect installing steam plant equipment for use over a limited period of the year.

On any sizable heating installation, a plant fuel balance, together with a complete study of capital and operating cost is essential in order to arrive at the proper and best solution of the problem.

In heating offices, in general, when steam is available, it is best to use radiators — I do not mean the old cast iron type, but some of the new thin-tube radiator types; or the high pressure pipe and steel fin type are better than the cast iron. Usually steam is available at pressures higher than the cast iron radiator will stand, and the heat distribution from a number of radiators is better than say a small number of unit heaters. Usually people working at desks do not like the noise of unit heaters or they do not like air blowing on them. So we have had more success with radiators in offices than with unit heaters.

On the other hand, some mill office people insist on unit heaters in the office because they serve the dual purpose of heating in the winter time and in the summer time they can be used for circulating air.

In the case of isolated offices, we have our problems there, also. We have tried many different types of heaters, including the smaller, domestic type of oil and kerosene burners. They were always getting out of order, were hard to maintain and were messy and a general nuisance. About four or five years ago, a manufacturer came out with an oil-fired air heater. That is an oil-fired space heater of about 80,000 Btu and another of about 100,000 Btu's. It has complete automatic control and recirculates air through a small duct system. The unit comes complete and usually the jobber in the particular area will install it, and it burns regular domestic fuel oil. We put a number of these in, and they are successful.

One other thing in connection with office heating, usually the complaints you get in office heating comes from the fact that people have cold feet, and even though the room is adequately heated their feet are cold, because most of our offices are directly down on the cement floor. The thing to do in that case is insulate the floor. A half inch of asphalt tile on the floor will do more to correct complaints on heating than adding more radiators or unit heaters.

Mr. Powell asked about, or mentioned heat lamps and radiant energy. That is another approach to the heating problem which I must admit I have not given too much consideration to because to me that is practically the same as having an open fireplace or in mill language a "bully." In other words, if you had a source of radiant heat and were working on one side of it, you would be warm in front and your back would be cold, unless you were able to place the heat lamps all around the person that is working — and it is kind of impractical to do that, in the mill. I do not doubt that this method of heating will find a place in our mills. However, it will be up to the suppliers of heat lamps, etc., to develop the application and acquaint plant heating engineers with their product. In other words we say to all suppliers, "When you have something new, show us what you have, how to use it, and we will find a place to use it."

Ventilation of STEEL MILL BUILDINGS

. . . . where ventilation is required in steelmaking processes, local units are generally the most efficient and effective . . . .

By WILLIAM S. JOHNSON
Industrial Hygienist
Bethlehem Plant
Bethlehem Steel Co.
Bethlehem, Pa.

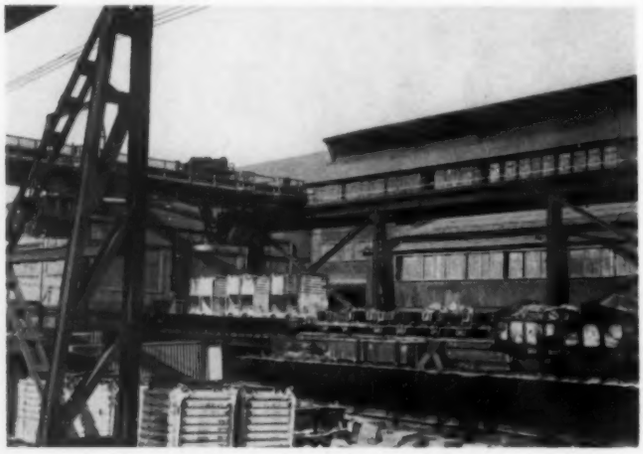
▲ UNFORTUNATELY, when most of our steel mill buildings were constructed, little thought was given to the problem of removing from the workroom atmosphere those contaminants which might result in occupational diseases. This unfortunate situation still exists and while construction and design have advanced by leaps and bounds within the past fifty years, there is still too little thought given to ventilation per se. There

Figure 1 — In the conventional mill buildings, monitors provide one of the chief sources for ventilation.

is a deep seated feeling among the designers and architects that doors and windows provide ample supply of air and the monitor roof ample exhaust. Such construction cannot alone be used for the modern steel industry because of the number of toxic agents which enter into the production of steel from the molten metal stage to the finished product, whatever it might be. Figure 1 shows a view in a conventional mill building. You will note that the monitor type roof is much in evidence. By comparison with Figure 2, you will not its ineffectiveness.

It is possible to provide to workroom atmosphere sufficient make-up air from a clean outside source to dilute the toxic contaminant to a point where it becomes acceptable from a standpoint of compliance with industrial hygiene codes. For example, visualize if you

Figure 2 — Monitors are, however, relatively ineffective.



can an area of 75 × 60 x 30 ft or a total cubage of 130,000 in which the finish-chipping of rolls is accomplished. Each of these rolls has at least two pounds of sand adhering to it which, when removed by pneumatic tools, generates a dust cloud. About ten such rolls are finished each day. This is a steel foundry operation, used for the purpose of illustration, and not to be confused with general remarks applying to steel plants. If this operation were to be controlled by general ventilation, it would require approximately 912,000 cu ft of air a minute to be passed through this building. This is at the rate of seven to eight complete air changes per minute. It is apparent that this rate of ventilation would make the heating of this space an utter impossibility. If this job of general ventilation were to be done by the conventional roof ventilator, it would require at least twenty-one 60-in. powered units to do this job. In other words, the apex of the roof would have fifteen 5-ft ventilators running from one end to the other with six more elsewhere on the roof. Would this impose an

Figure 3 — Exhaust outlets provide general ventilation, but are inefficient for many applications.

extra problem for the structural designer of this building? This same operation could be adequately controlled using a ventilated floor grill and lateral slot type ventilation with a consumption of only about 180,000 cu ft.

At one steel plant where manual scarfing is done, the bay is ventilated by twelve 60-in. roof-type ventilators having a capacity of 42,500 cfm each. There is removed from this bay each minute 520,000 cu ft of air. There is no question that this improves conditions. However, the amount of iron oxide present in fume form is still higher than desirable. If local exhaust ventilation were applied here, with a humpbacked hood for each scarfing station, each connected with a common exhaust duct,

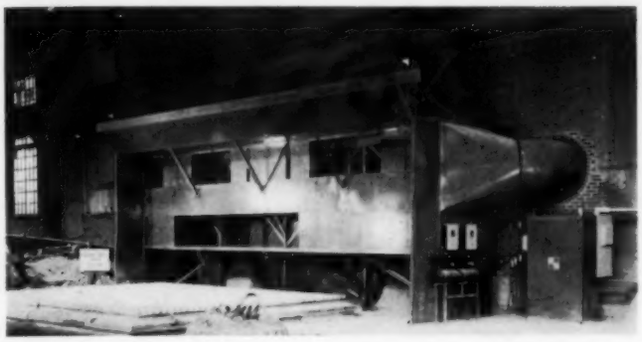


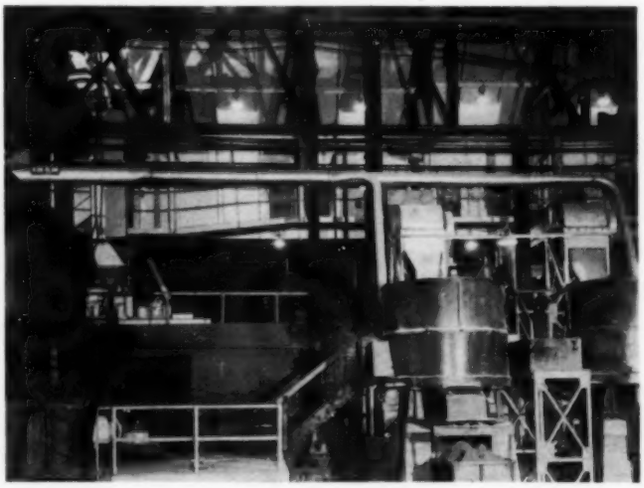
Figure 4 — Local exhaust ventilation is the most efficient, particularly for very dusty operations.

140,000 cfm would adequately remove all of the scarfing fume, resulting in decreased power cost and a safer place to work.

At a small steel company not too far distant, the problem of removing from the furnace-floor area the iron oxide generated by six electric furnaces of medium capacity was attempted by the use of general ventilation. Twenty 48-in. roof ventilators and seven 60-in. exhaust fans were installed to provide an exhaust rate of 1,500,000 cfm. After the installation had been completed, the City Health Department condemned the installation because of its utter inadequacy. The problem was eventually solved by the use of furnace hoods and the total exhaust rate reduced to 120,000 cfm. The use of supplied air from dilution, therefore, becomes prohibitive in most cases from an economic standpoint both because of loss of heat and the tremendous quantity of air which must be removed. Unfortunately, the use of hoods and exhausters on fifty and seventy-five ton electric furnaces has not been successful. Such use is still in the development stage. In general, for any process in the steelmaking business where ventilation is required in order to provide a healthy working atmosphere, in most cases, general ventilation will not do. The remainder of this paper will discuss other acceptable methods of providing safe workroom atmospheres, principally that of local exhaust ventilation.

In the steelmaking process, there are a number of operations requiring control which are connected either directly or indirectly with the production of a finished product. For example, the shake-out or knock-out of steel castings creates both an undesirable and dangerous situation as regards dust concentrations. The solution of this problem was attempted by general ventilation. In the roof of this building there are three large-volume powered exhaust outlets (see Figure 3) moving a tremendous quantity of air per minute (45,000), almost 135,000 cu ft per min for the three units. This problem was not solved by the installation of this equipment. Figure 4 shows a shake-out hood which was installed for this operation. This is a good example of local exhaust ventilation. The dimensions of the hood are 40 × 15 ft with each of the fans behind the hood moving 53,000 cu ft of air per min, a total of 159,000 cfm. The result of this installation has been that dust concentration in this area has now been reduced to a level where the air is safe for men to breathe. Figures 5 and 6 show the complete exhaust ventilation of a mechanized sand-handling operation. Prior to this installation, dust concentrations within this building were above the acceptable limit and could not be reduced satisfactorily by general ventilation, that is roof ventilators, wall fans, etc. Following the installation of this equipment, the dust concentrations were reduced to a level nearly corresponding to the outside air.

Figure 5 — Illustration shows exhausted sand handling equipment.



The acid treatment of steel is a widely used method for the removal of scale and oxide. Such treatment always throws into the surrounding atmosphere microscopic particles of acid mist and acid vapor. The correction of this situation is often attempted by general ventilation and the operation and control depicted by Figure 7 was attempted by a pseudo-exhaust ventilation. In the wall of the area behind the stacks noted on the figure there had been placed three large openings at a level of about six feet above the tanks. These openings exhausted from the area about 5000 to 6000 cfm. Control was not obtained and due to peculiar air currents set up in this particular building, the vapor mist from the tanks was carried for a distance of forty yards and deposited upon men and machinery working in that area. Correction of this situation was obtained by the method shown; that is lateral slot-exhaust ventilation of each of the tanks. A volume of 105,000 cfm is now being removed from this area and the situation is well under control, as shown by the movement of steam, vapor and mist into the slots.

The use of refractory materials in the steelmaking business is widespread. The preparation of open hearth bottom materials, refractory cements, and other finely divided materials is commonly done in mullers. When dry materials are used, even with the addition of water, this operation throws into the air dangerous quantities of dust. Figure 8 shows a design for the correction of such a situation. You will note that the muller is completely enclosed by a hood and that feeding of the elevator which supplies the muller is accomplished through a ventilated hood where barrow loads of material can be dumped without danger of throwing excessive quantities of dust into the air. This type of local exhaust ventilation can be applied to any operation which is polluting the atmosphere to the detriment of the workers.

In some rolling-mill operations it is desirable to

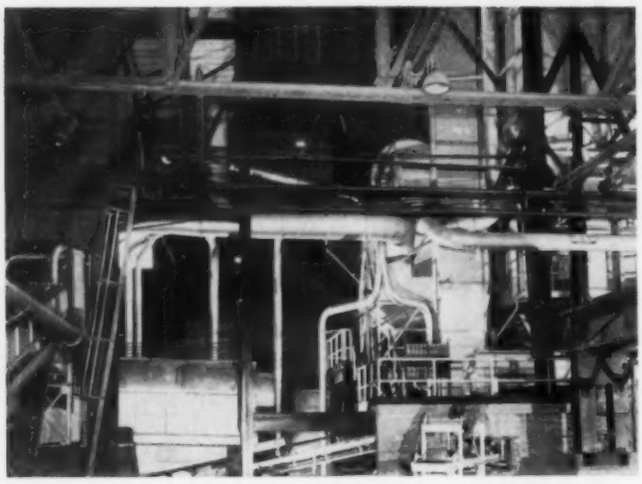


Figure 6 — Another view of the exhausted sand handling equipment.

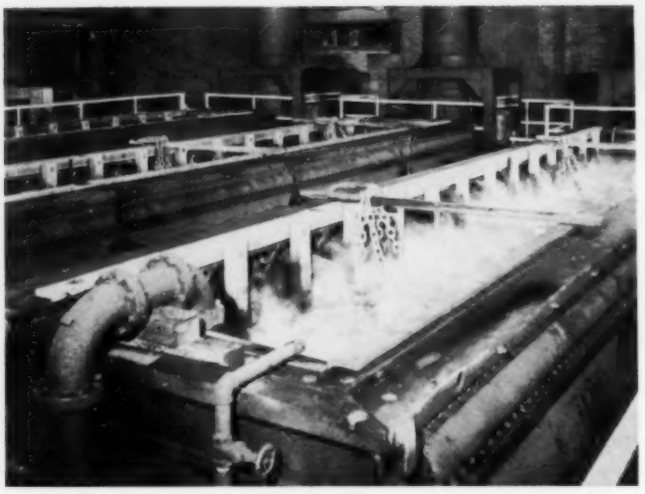


Figure 7 — These pickling tanks have lateral exhaust ventilation.

remove the iron oxide evolving from those operations. In this case a general ventilation of those areas, that is, the placing of sufficiently powerful roof ventilators over the offending operation, is perhaps the most acceptable method of removing the oxide. The placing of local exhaust hoods over the rolls is possible, and Figure 9 shows the design of such an arrangement. However, because of the time required for the removal of hoods prior to roll changes, it is not considered an entirely satisfactory solution and until a satisfactory method can be designed which will make use of local exhaust ventilation, it is only here general ventilation proves of any value in the steelmaking process, and it is even doubtful in this case.

Since heat and its dissipation is a problem which has long plagued steel manufacturers, I think it not amiss to introduce at this point the relationship of general ventilation to the dissipation of heat in rolling mills, or for that matter in any other hot process. The powered roof ventilators are common to all rolling mill buildings, as are the use of large man-cooler fans. Most of us present know that the problem has not been solved by ventilation. Air can be moved across, through and around processes involving molten and incandescent metal without dissipating the heat one iota. This heat is radiant heat and its effect on both workmen and building structures is to radiate both to body surfaces and otherwise, so much heat that equilibrium cannot be

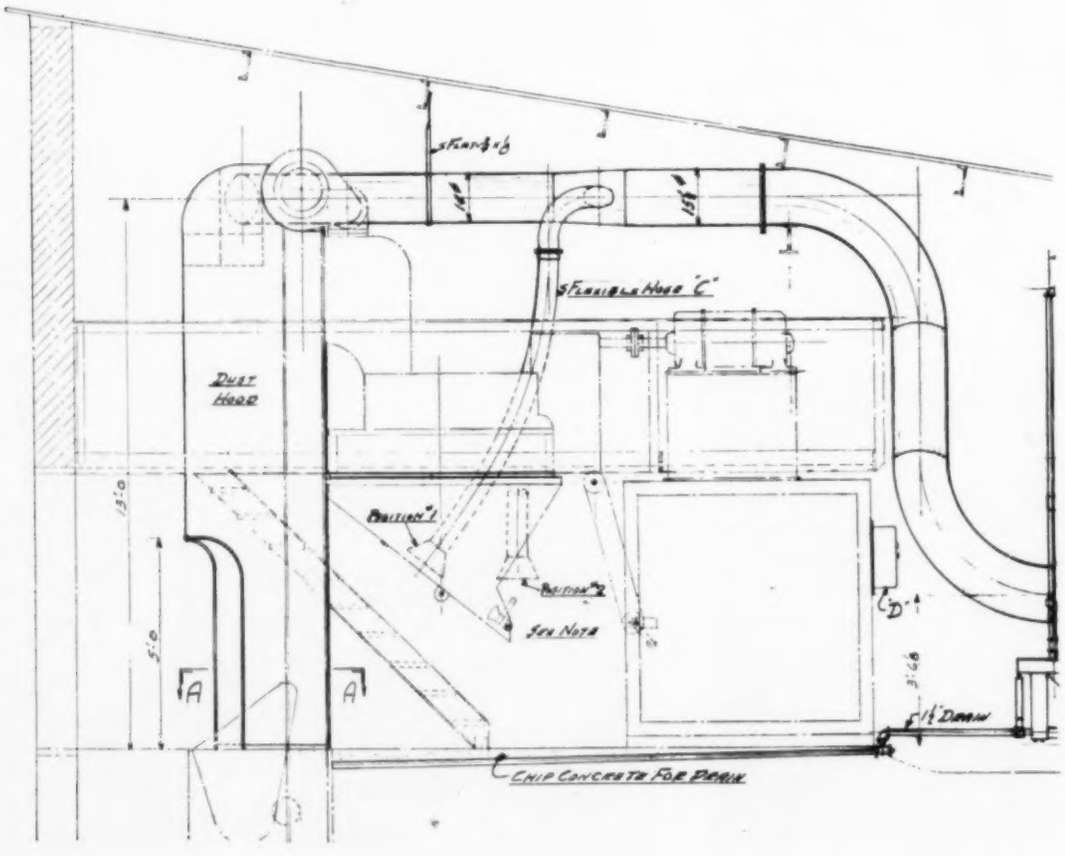


Figure 8 — Plan of muller enclosure and ventilation which is provided.

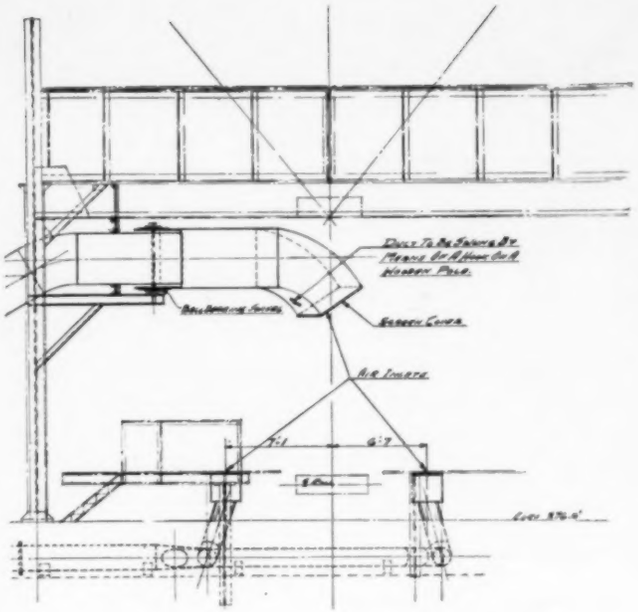


Figure 9 — Local exhaust hoods are provided over the rolls to provide oxide removal from the finishing mill.

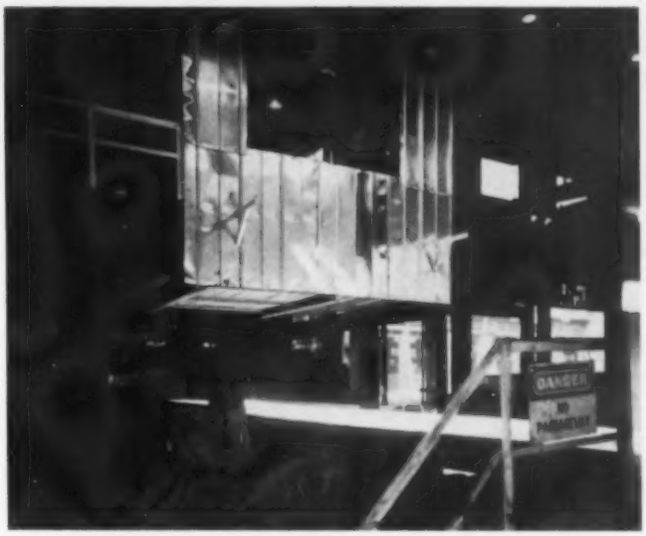


Figure 10 — Ventilation provides little alleviation for discomfort from radiant heat. Aluminum shielding may, however, be used very effectively.

maintained by evaporation from the body or conduction and convection from building surfaces. All of us have seen, at one time or another, banks of man-coolers blowing on the operators of large forges, blooming mills, shearmen, saw operators, etc. It is true that the air movement gained through these fans, depending on the dewpoint, does produce the evaporation of the men's perspiration, but it does not effect in the least the radiant heat which is continually passing to a man a greater heat load than his body can successfully dissipate. It would seem, therefore, that this problem cannot be solved. Fortunately for us this is not the case. Figures 10 and 11 illustrate a solution which has nothing to do with ventilation other than to make it unnecessary to move such tremendous quantities of air in these hot processes. The method involves the application of a physical principle known to all but until very recently never applied. It is the principle of reflecting the infra-red spectrum by using suitable materials, principally aluminum, which have the ability to do so. Figure 10 a rolling mill pulpit, shielded on sides and bottom, reflecting all heat from the line below back to its source.

DISCUSSION

PRESENTED BY

HUGO R. PHILLIPS, Mechanical Engineer, Bethlehem Steel Co., Sparrows Point, Md.

WILLIAM S. JOHNSON, Industrial Hygienist, Bethlehem Plant, Bethlehem Steel Co., Bethlehem, Pa.

Hugo R. Phillips: Mr. Johnson, you spoke only incidentally of man-coolers for conveying heat away from hot surfaces, etc. We have a similar problem, only in maintenance, in trying to cool men from hot brick such as in checker cleanout and furnace rebuilding. Have you had any experience or have you any suggestions on that which we may be able to apply?

William S. Johnson: That subject comes under the subject of individual personnel protection. While we have more or less pioneered in this matter of heat reflection at Bethlehem, some work has also been done in the glass industry, which is also a hot industry. We have attempted in only a few cases to protect personnel from heat, but they (the glass industry) have done a great deal more work in providing aprons and clothing which is either aluminum backed or is a fibre glass material sprayed with aluminum paint. Aluminum paint is not nearly as good as aluminum in reflecting the infra-red spectrum. It is only about 40 per cent efficient, but it does a better job than any other kind of paint.

The matter of heat reflection is not new; it is just that we have not used enough of it. It is a broad subject and could be discussed for hours on end to the advantage of all of us.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill", published by the Association of Iron and Steel Engineers. If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BUILDING, PITTSBURGH 22, PA.

Program

1951 AISE CONVENTION
HOTEL SHERMAN
CHICAGO, ILL.

Monday, October 1

9:00 am — REGISTRATION — First Floor Lounge

9:00 am — LADIES REGISTRATION AND HEADQUARTERS — Mezzanine Floor

A program of ladies activities will be available upon registration.

9:30 am — BUSINESS MEETING — Louis XVI Room Conducted by I. N. Tull.

10:00 am — ELECTRICAL SESSION — Louis XVI Room

Chairmen: R. W. Graham, Superintendent Electrical Department, Bethlehem Steel Co., Lackawanna, N. Y.
W. J. Tunny, Superintendent Electrical Maintenance, Youngstown Sheet and Tube Co., East Chicago, Ind.

"Multiple Generators for Processing Lines," by E. E. Vonada, Application Engineer, Reliance Electric and Engineering Co., Cleveland, Ohio.

"Increased Interrupting Capacity in Fuses," by John C. Lebens, Chief Engineer, Bussmann Manufacturing Co., St. Louis, Mo.

"Has Industrial Tractor Design Kept Pace with Steel Mill Operating Requirements?" by Carleton Lord, Material Handling Engineer, United States Steel Co., Pittsburgh, Pa.

10:00 am — COMBUSTION SESSION — Crystal Room

Chairmen: C. W. Bruce, Chief Engineer, Republic Steel Corp., South Chicago, Ill.
E. A. Hawk, Fuel Engineer, Tennessee Coal, Iron & Railroad Co., Ensley, Ala.

"Combustion Gas Turbines and the Steel Industry," by W. B. Wilson, Application Engineer, Industrial Power Div., General Electric Company, Schenectady, N. Y.

"Viscosity Control of Fuel Oil for Open Hearths," by Harvey Krouse, Field Engineer, Fischer and Porter Co., Pittsburgh, Pa.

2:00 pm — MECHANICAL SESSION — Crystal Room

Chairmen: L. F. Coffin, Superintendent Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.
James J. Healy, Project Engineer, Armco Steel Corp., Middletown, Ohio.

"Metallurgical Tips for the Maintenance Man," by Michael V. Herasimchuk, Maintenance Metallurgist, Bethlehem Steel Co., Bethlehem, Pa.

"Accurate Steel Mill Weighing," by K. A. Blom, Corporation Weighing Supervisor, Republic Steel Corp., Cleveland, Ohio.

"Crane Runway Maintenance," by H. Russell Knust, Assistant Superintendent, Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.

2:00 pm — OPERATING PRACTICE SESSION — Louis XVI Room

Chairmen: Arthur K. Blough, Superintendent No. 2 and No. 3 Melt Shops, Republic Steel Corp., Canton, Ohio.
W. J. Reilly, Manager, Steel Mill, Ford Motor Co., River Rouge, Mich.

"Production Characteristics of the Open Hearth," by H. F. Lesso, Open Hearth Control Metallurgist, Great Lakes Steel Corp., Ecorse, Mich.

"A Comparison of Electric Furnace and Open Hearth Economics," by H. W. McQuaid, Consulting Metallurgical Engineer, Cleveland, Ohio.

"Heat Relief in Hot Industries," by B. R. Small, Staff Engineer, Mechanical Engineering Dept., Aluminum Co. of America, Pittsburgh, Pa.

Tuesday, October 2

9:00 am — ELECTRICAL SESSION — Louis XVI Room

Chairmen: James D. O'Roark, Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.
C. G. Dimitt, Supervisor Design Engineering — Electrical, United States Steel Co., South Chicago, Ill.

"Coal and Ore Bridges," by E. L. Blankenbeker, Electrical Engineer, Heyl & Patterson, Inc., Pittsburgh, Pa.

"Modern A-C — D-C Crane Control for Steel Plants," by W. R. Wickerham and G. E. Mathias, Control Engineering Department, Westinghouse Electric Corp., Buffalo, N. Y.

"Crane Wheel Tread Contours," by John J. Stolz, Chief Engineer, The Tool Steel Gear & Pinion Co., Cincinnati, Ohio.

9:00 am — ROLLING MILL SESSION — Crystal Room

Chairmen: Wade F. Hoffman, Superintendent Roll Department, Jones & Laughlin Steel Corp., Aliquippa, Pa.
J. J. Booth, Assistant to General Superintendent, United States Steel Co., Duquesne, Pa.

"Roll Turning with Tracer Controlled Lathe," by Frank F. Zipf, Superintendent Roll Department, Bethlehem Steel Co., Johnstown, Pa.

"The United-Rendleman Rod Mill," by Norman Rendleman, Special Consultant, United Engineering & Foundry Co., Pittsburgh, Pa.

"Operation of a 12-in. Continuous Bar Mill," by A. H. Griffiths, Superintendent of Rolling Mills, Sheffield Steel Corp., Kansas City, Mo.

1:00 pm — INSPECTION TRIP — Gary Sheet & Tin Mill, United States Steel Co., Gary, Ind.

6:30 pm — OLD TIMERS' DINNER — Louis XVI Room

Wednesday, October 3

9:00 am — LUBRICATION SESSION — Crystal Room

Chairmen: Andrew Cichelli, Lubricating Engineer, Bethlehem Steel Co. Sparrows Point, Md.
Frank L. Gray, Lubrication Engineer, United States Steel Co., Gary Works, Gary, Ind.

"Lubrication of Wire Rope," by C. H. Layton, Assistant Chief Rope Engineer, Hazard Wire Rope Div. & American Cable Div., American Chain & Cable Co., Inc., Wilkes-Barre, Pa.

"Quality Control of Lubricants," by Carlyle R. Burton, Superintendent of Maintenance, Hibbing-Chisholm District, Oliver Iron Mining Co., Hibbing, Minn.

"Spray Lubrication of Open Gears," by Joseph A. Rigby, Vice-President, Engineering — Sales, The Brooks Oil Co., Pittsburgh, Pa.

9:00 am — COMBUSTION SESSION — Louis XVI Room

Chairmen: G. J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.
R. A. Lambert, Superintendent Steam and Combustion, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"A New Method of Annealing Coils," by Lee Wilson, Lee Wilson Engineering Co., Inc., Cleveland, Ohio.

"High Temperature — High Speed Heating for Steel Rounds," by A. F. Kritscher, Development Engineer, National Tube Co., Pittsburgh, Pa.

"Operative Results of One-way Fired Recuperative Soaking Pits," by Jas. C. Stamm, Jr., Field Engineer, Fuel Department and E. H. Cauger, Chief Combustion Engineer, Wheeling Steel Corp., Steubenville, Ohio.

2:00 pm — GENERAL SESSION — Ball Room

Chairman: I. N. Tull, Electrical Superintendent, Republic Steel Corp. Cleveland, Ohio.

An address by H. W. Johnson, Vice President, Inland Steel Co., Chicago, Ill.

3:00 pm — STANDARDIZATION SESSION — Louis XVI Room

Chairman: Leo J. Gould, Chief Engineer of Construction, Bethlehem Steel Co., Bethlehem, Pa.

"Report of Activities of AISE Standardization Committee — 1951," by L. J. Gould, Chairman, AISE Standardization Committee.

"Carbon Brush Size and Shunt Standard — Final Report," by E. L. Anderson, Chairman, AISE Carbon Brush Standardization Committee.

"A Mill Motor Brake Standard — Final Report," by V. E. Schlossberg, Chairman, Mill Motor Brake Standardization Committee.

"Wiring Standard — Progress Report," by J. E. Bodoh and C. G. Dimitt, Chairmen, Wiring Standards Committee.

"American Recommended Practice of Industrial Lighting A-11," by J. J. Booth, Chairman, Steel Mill Lighting Committee.

"Development of Steel Plant Air Filter Data — Initial Report," by A. H. Arbogast, Chairman, Steel Plant Air Filter Committee.

3:00 pm — OPERATING PRACTICE SESSION — Crystal Room

Chairmen: A. F. Kritscher, Development Engineer, National Tube Co. Pittsburgh, Pa.
Paul E. Thomas, Assistant General Superintendent, United States Steel Co., Gary, Ind.

"Latest Developments in Extrusion of Metals," by Erwin Loewy, President, Loewy Rolling Mill Division, and Hydropress, Inc., New York, N. Y.

"Phosphate Coatings as Lubricants in the Severe Cold-Forming of Metals,"
Part I — General Description, by S. Spring, Group Leader, Research and Development Div., Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Part II — Application, by Dr. Ludwig K. Schuster, Chief Chemist, Heintz Manufacturing Co., Philadelphia, Pa.

7:30 pm — FORMAL DINNER AND DANCE — Grand Ball Room — Hotel Sherman

Thursday, October 4

9:00 am — ELECTRICAL SESSION — Crystal Room

Chairmen: Malcolm B. Antrim, Superintendent Electrical Maintenance, Lukens Steel Co., Coatesville, Pa.
W. A. Perry, Assistant General Superintendent, Service, Inland Steel Co., East Chicago, Ind.

"Rectifier Application for Steel Mill Drives," by George B. Scheer, Chief Consulting Electrical Engineer, Kaiser Engineers, Division of Kaiser Industries, Inc., Oakland, Calif.

"Control of Demand and Power Factor on Electric Arc Furnaces," by H. G. Heath, Electrical Engineer, Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa.

"A-C Power Distribution in Steel Mills," by D. L. Beeman, Manager, Industrial Power Division, General Electric Co., Schenectady, N. Y.

9:00 am — OPERATING PRACTICE SESSION — Louis XVI Room

Chairmen: C. G. Hogberg, Assistant to Chairman, Blast Furnace Committee, United States Steel Co., Pittsburgh, Pa.
F. M. Rich, General Superintendent, Inland Steel Co. East Chicago, Ind.

"Cleaning of Industrial Gases," by Jay J. Seaver, Manager, Jay J. Seaver Engineers, Chicago, Ill.

"The Axial Compressor for Blast Furnace Blowing," by W. O. Lowell, Blower and Condenser Section, Mechanical Power Department, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

2:00 pm — OPERATING PRACTICE SESSION — Louis XVI Room

Chairmen: John E. Angle, Assistant General Superintendent, Gary Sheet & Tin Mill, United States Steel Co., Gary, Ind.
Leonard Larson, Chief Engineer, Republic Steel Corp., Cleveland, Ohio.

"Rolling of Thin Strip," by M. D. Stone, Manager of Development, United Engineering & Foundry Co., Pittsburgh, Pa.

"Differential Thickness Coating on Electrolytic Tinplate," by S. S. Johnston, Technical Director, Electrolytic Dept., Weirton Steel Co., Weirton, W. Va.

"Flash Welding and High Speed Cold Reduction of Strip Steel for Tin Plate," by John Wargo, Assistant Tin Plate Metallurgist, and Ray C. Brunner, Development Engineer, Jones & Laughlin Steel Corp., Aliquippa, Pa.

2:00 pm — LUBRICATION SESSION — Crystal Room

Chairmen: D. N. Evans, Assistant Master Mechanic, Inland Steel Co., East Chicago, Ind.
D. E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

"The Application of Bentone Lubricants to the Steel Industry," by D. H. Compondu, Product Engineer, The Warren Refining & Chemical Co., Cleveland, Ohio.

"Standardization in the Lubrication Department," by J. D. Lykins, Chief Lubrication Engineer, Wheeling Steel Corp., Wheeling, W. Va.

"Reconditioning Air Filter Oils," by George Findlay, Lubrication Engineer, Republic Steel Corp., Buffalo, N. Y.

NOTICE!

The papers on this program, together with the convention discussions, will be published in future issues of the IRON AND STEEL ENGINEER

Authors

E. L. ANDERSON

D. L. BEEMAN

E. L. BLANKENBEKER

K. A. BLOM

MICHAEL

J. J. BOOTH

RAY C. BRUNNER

CARLYLE R. BURTON

E. H. CAUGER

A. F

D. H. COMPONDU

GEORGE FINDLAY

L. J. GOULD

A. H. GRIFFITHS

H

1951 AISE Annual Convention

MICHAEL V. HERASIMCHUK

H. W. JOHNSON

S. S. JOHNSTON

H. RUSSELL KNUST

A. F. KRITSCHER

HARVEY KROUSE

C. H. LAYTON

JOHN C. LEBENS

H. F. LESSO

ERWIN LOEWY

CARLETON LORD

W. O. LOWELL

Authors

J. D. LYKINS

G. E. MATHIAS

H. W. McQUAID

NORMAN RENDLEMAN

JOSEPH A. RIGBY

GEORGE B. SCHEER

V. E. SCHLOSSBERG

DR. LUDWIG K. SCHUSTER

JAY J. SEAVER

Authors

S. SPRING

B. R. SMALL

JAS. C. STAMM, JR.

JOHN J. STOLZ

M. D. STONE

E. E. VONADA

JOHN WARGO

W. R. WICKERHAM

W. B. WILSON

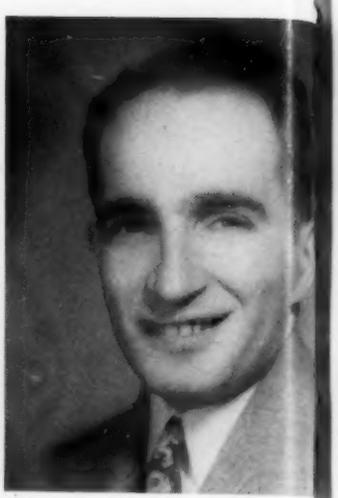
FRANK F. ZIPF

Chairmen

JOHN E. ANGLE

MALCOLM B. ANTRIM

C. W. BRUCE



ANDREW CICHELLI

L. F. COFFIN

D. N. EVANS

R. W. GRAHAM

W.

FRANK L. GRAY

JAMES J. HEALY

WADE F. HOFFMAN

C. G. HOGBERG

1951 AISE Annual Convention

R. A. LAMBERT

LEONARD LARSON

JAMES D. O'ROARK

W. A. PERRY

W. J. REILLY

F. M. RICH

PAUL E. THOMAS

I. N. TULL

W. J. TUNNY

D. E. WHITEHEAD

Abstracts of Papers

To be presented at

AISE ANNUAL CONVENTION

HOTEL SHERMAN
CHICAGO, ILL.

OCTOBER 1, 2, 3 and 4, 1951

"MULTIPLE GENERATORS FOR PROCESSING LINES"

by E. E. VONADA, Application Engineer, Reliance Electric and Engineering Co., Cleveland, Ohio

▲ THE author discusses in some detail the trend toward use of individual generators to supply adjustable voltage power for the motors driving the various units in a modern high speed processing line.

Layouts of two somewhat different tinning lines, each equipped with a new multiple generator system of power supply for individual motor drives, are compared and advantages enumerated. Simplification of bus structures, less expensive breakers and the use of higher speed generators are important economies insofar as the electrical installation alone is concerned. Greater flexibility in adjusting for the use of standard gear reduction units and for changes in diameter of rolls over which the strip travels are other advantages listed.

Development of a "fade-in" system of motor speed control and synchronization when adjustable speed motors are used as in processing lines where the character of the loading falls between constant torque and constant horsepower. Specific data is supplied covering the "horsepower-speed" relationship for a 20-hp drag-motor operated under this "fade-in" control to drive a four roll tension bridle in a new galvanizing line.

"INCREASED INTERRUPTING CAPACITY IN FUSES"

by JOHN C. LEBENS, Chief Engineer, Bussmann Manufacturing Co., St. Louis, Mo.

▲ THROUGHOUT the past fifteen years fusetron dual-element fuses have been used extensively for the protection of power circuits in steel mills because their increased time-lag eliminates needless blows caused by harmless overloads produced by motors starting, capacitor switching, and the like. At first no data on the interrupting capacity of the dual-element fuses were available. When used on large capacity circuits where high short-circuit currents were possible, the users were forced to take a chance and use the dual-element fuse as the sole protection or back up the fuses with expensive circuit-breakers having adequate interrupting capacity.

Neither alternative was entirely satisfactory. The first placed an unreasonable responsibility on the operating electrical engineer and the second was basically unsound because, under short-circuit conditions, the circuit-breaker is slower acting than the fuse. Hence, if the fuse did not have adequate interrupting capacity, it would blow up before the breaker could operate to protect it.

By 1947 the field experience on the dual-element fuse had been so satisfactory that complete interrupting capacity information was mandatory. Unfortunately, it was practically impossible to find 240 or 480-v circuits with sufficient capacity for the determination of the interrupting capacity of dual-element fuses. However, in the last several years such a circuit was made available and the knowledge gained by tests on it made possible the redesign of the fuse, increasing its interrupting capacity. The paper describes the results of this development, giving actual test data on the fuses commercially available today for the protection of steel mill power circuits.

"COMBUSTION GAS TURBINES AND THE STEEL INDUSTRY"

by W. B. WILSON, Application Engineer, Industrial Power Division, General Electric Co., Schenectady, N. Y.

▲ THE combustion gas turbine is an important new tool for the power engineer in the iron and steel industry. This industry is a large user of electric power and often supplements power purchased from the utility with power generated within the mill. Power generation within the mill becomes more attractive, of course, when "low-cost" by-product fuel can be utilized.

The simplicity, low first cost, and expected low maintenance and operating costs of combustion gas turbines make them applicable in many mills where power generation is considered. They can be used for power generation, for blower drive, or for other mechanical drive applications.

This paper discusses the types of combustion gas turbines for various applications with particular attention to possible applications in the iron and steel industry. Ratings, fuels and performance data are given for the different types of units. The operating experience accumulated on units now in service will also be discussed.

"METALLURGICAL TIPS FOR THE MAINTENANCE MAN"

by MICHAEL V. HERASIMCHUK, Maintenance Metallurgist, Bethlehem Steel Co., Bethlehem, Pa.

▲ SOLVING problems on equipment failures is sometimes difficult for the maintenance man because the original metallurgical or engineering factors of design are seldom reviewed with him. To help him recognize when equipment failures are related to metallurgical or engineering principles, this paper presents field studies made on steel mill equipment. It shows how failures have been forestalled or eliminated and points out how the maintenance man is an important part of a failure research program.

Illustrations include (a) the effective use of alloy steel, (b) the effect and correction of inadequate design, (c) the effect of improper welding practice, (d) the effect and correction of improper heat treatment specifications. Further illustrations show how to combat effects of decarburization and stress raisers, and how to study tool wear problems. Emphasis is placed on the importance of relaying accurate information to both engineering and metallurgical departments.

"VISCOSITY CONTROL OF FUEL OIL FOR OPEN HEARTHS"

by HARVEY KROUSE, Field Engineer, Fischer and Porter Co., Pittsburgh, Pa.

▲ OPEN hearth operators and combustion engineers have recognized for many years the variations in viscosity of the "bunker C" fuel oils and the unfavorable effects of these viscosity variations on uniform firing and combustion control of their open hearth furnaces. Since the fuel oils as supplied from the sources are not uniform in consistency, the conventional temperature control of the recirculating fuel oil to the open hearth does not eliminate the effects of this viscosity variable. The objective has been to employ a control device that will sense and maintain a given viscosity.

A viscometer has been developed and utilized for continuously measuring viscosity of fluids in kinetic units based on the reciprocal of the principle of viscosity compensating floats of the area-type flow meter commonly referred to as the rotameter. Installed in a sampling stream downstream from the heat exchanger in the recirculating fuel oil system, the viscometer is equipped with two metering floats in a common metering tube. One float, being viscosity compensating, controls flow through the viscometer while the second one being sensitive to viscosity changes measures this variable.

By suitable transmission to exhibiting instruments, flow and viscosity are recorded and pneumatic-controlling mechanisms are actuated. The pneumatic impulses from the viscosity-controlling instrument throttles a diaphragm-operated valve installed in the steam supply line to the fuel oil heat exchanger.

Where this equipment has been installed, the anticipated results have been obtained. Comparison of simultaneous chart records show that a mean preset viscosity magnitude has been maintained over a 24-hour period with the temperature of the oil taken downstream from the heat exchanger varying over a gradual swing during the same time period. Guided by the performance of the original installations, a design change has been effected in the viscometer whereby flow control is maintained by a weight type differential pressure regulator substituting for the original flow-controlling metering float. Viscosity measurement and control are performed by the same viscosity-sensitive float.

"ACCURATE STEEL MILL WEIGHING"

by K. A. BLOM, Corporation Weighing Supervisor, Republic Steel Corp., Cleveland, Ohio

▲ ACCURATE and dependable weighing is a matter of major importance, since a number of significant calculations are based on weights. In recognition of this fact, Republic Steel Corp. has instituted a weighing program designed to modernize and otherwise improve all major scale installations. The program is directed by a weighing committee appointed by the management of the corporation and consisting of representatives from all departments concerned.

Track scale checkweighing of outbound products have been eliminated and in order to establish close control of mill weighing, each steel producing district of the corporation furthermore employs a weighing supervisor, whose sole duty it is to follow all phases of weighing within their respective districts. Every shipping scale in the corporation, as well as a great number of production scales, has in the past three years been furnished with up-to-date, self indicating recording dials, in an effort to eliminate human errors resulting from beam and poise weighing. Scales are tested regularly and any errors in excess of $\frac{2}{10}$ of 1 per cent promptly corrected by a well equipped scale repair force.

Special attention is being paid to scale repairs and maintenance, particularly preventive maintenance. Scale repair shops in each steel district have been properly equipped with all the facilities required to repair any type of scale quickly and efficiently. In some of the larger districts a fully equipped scale service truck is used to facilitate quick repairs.

Shock loading of scales is probably the most frequent cause of scale trouble. This practice results in broken levers, pivots, cut bearings or at the best in jarring knives and pivots off their bearings. To overcome this, Republic has through special arrangement with the

manufacturer, introduced a specially designed flexure plate scale for mill weighing. Besides eliminating scale wear completely, this type scale offers greater resistance to shock through greater bearing surface and insures maximum stability of scale multiplication. Following the presentation of the paper, a short movie and a few slides will be shown on the subject of flexure plate scales, their installation and subsequent performance.

"CRANE RUNWAY MAINTENANCE"

by H. RUSSELL KNUST, Assistant Superintendent, Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.

▲ THE paper covers some of the methods and procedures necessary for proper crane runway maintenance in a large integrated steel plant. It deals with methods of repairing rail joints, changing rails, and what is believed to be a new idea in the method used to fasten rails to crane runway girders. The failures encountered in crane runway girders, both of the built-up box type and the rolled-section type are discussed. This will include worn cover plates, broken diaphragms, failures of the web, end to end connections, etc., and the repair methods used for correction of same. The question of crane runway misalignment is touched on briefly with some examples of methods used for correction.

"PRODUCTION CHARACTERISTICS OF THE OPEN HEARTH"

by H. F. LESSO, Open Hearth Control Metallurgist, Great Lakes Steel Corp., Ecorse, Mich.

▲ The paper covers an extensive survey of hearth patterns in dimension relationships, relative capacities and fuel input characteristics, etc., of a number of furnaces.

The analytical data is developed in three phases:

a. An analysis of approximately 85.0 per cent of the basic open hearth furnaces in the United States, these data revealing the present day status on a representative basis of the preferred hearth patterns, capacities, etc., of the industry's steel producing furnaces. The findings being illustrated and tabular data is given.

b. An extensive survey of the production characteristics based upon increasing ton fractions per square foot of hearth area on nine furnaces covering a period of ten years. The ten-year operating period is analyzed on a basis of operating furnace years. The total operating furnace years included in the study is 67, and represents 44,695 heats and 10,190,000 tons of ingots.

c. The concluding phase of the paper is a detailed study of twenty individual furnace campaigns, representing over 3600 heats or equivalent to 900,000 tons of ingots. The analysis includes eighteen specific operating phases.

"A COMPARISON OF ELECTRIC FURNACE AND OPEN HEARTH ECONOMICS"

by H. W. McQUAID, Consulting Metallurgical Engineer, Cleveland, Ohio

▲ THIS paper discusses in some detail the fundamental economic factors underlying the general steel industry and how they affect the choice of a melting unit. The question of location and size of markets, the type of finished products, and the general factors of supply and demand under present conditions and how they affect the choice of a melting unit are reviewed. At the same time, the difference in melting requirements under different degrees of integration and how these affect investment and operating costs are discussed and some of the limitations of the large tonnage fully integrated plants pointed out.

The present problems of freight absorption, delivery priority, and steel shortages of a large group of steel users are discussed and their effect on the demand for the installation of new steel producing equipment closer to the markets is noted. The subject of the economics of the small semi-integrated steel production unit in the more remote areas and what will be necessary to develop such plants is also discussed.

A comparison is made between the economics of the production of ingots of electric furnace steel and the same grade of steel in ingots of open hearth steel. The investment required is compared for different sized units as is the finished cost in material and the cost above material for a hot metal and cold pig iron open hearth shop and a really modern electric arc furnace melt shop.

Examples are given of the investment and production costs for different applications and the advantages of the electric furnace over the cold iron open hearth are noted. The large fully integrated hot metal open hearth plant is still able to produce more cheaply than the modern electric but only at a substantially greater investment all along the line.

It is shown that one field for the electric melting furnace will be in its use in relatively small section ingots or the continuous casting process which permits rods, piercing billets and hot strip to be rolled directly from the cast ingot. The present status of this development is discussed with the conclusion that the logical continuous casting section is the wide slab of limited thickness.

The direct reduction of ore with the new low cost hydrogen now available promises in the near future to supply a charge material which will supplement scrap and tend to stabilize scrap prices and thus insure a charge for the electric furnace which will overcome the serious economic disadvantages of scrap as at present. This will make it more difficult for the open hearth even when operating on hot metal to produce ingots at a cost which is competitive with the modern high powered electric arc furnace. This development is discussed in some detail.

It is concluded that the future of the electric furnace lies in its contribution to the decentralizing of

the steel industry. It provides the basis on which relatively small steel plants can be located in steel consuming markets at present relatively remote from the steel producing centers and supply these markets with standard or special steel products more economically than by any other means. It is pointed out that with the development of continuous casting and hydrogen reduced iron ore, there is a very strong possibility that the position of the open hearth may, in the not too distant future, be threatened in all but a few large steel making centers by the high powered modern arc furnace.

"HEAT RELIEF IN HOT INDUSTRIES"

by B. R. SMALL, Staff Engineer, Mechanical Engineering Dept., Aluminum Co. of America, Pittsburgh, Pa.

▲ THE metal producing industries are obtaining increased returns from investments that provide employee relief from excessively hot working conditions. Industrial ventilation now utilizes radiant heat shielding at furnaces, local or spot air cooling and crane cab air conditioning. Increased building ventilation rates are made possible by use of fan-powered roof ventilators, either conventional round wind-band design or the more convenient blackout or dome top styles.

Recently developed methods of radiant heat shielding by portable reflective sheet metal curtains have aroused considerable enthusiasm among operating crews and supervisors. About 90 per cent of the radiant heat from a hot furnace shell or brickwork surface can be intercepted by a curtain that comes to equilibrium only 20 F above room air temperature. The convective component is dissipated as hot air through existing roof ventilators. In certain situations rather startling results have been obtained by this method at a fraction of the cost of supplementary ventilation.

For severe conditions that are unsuited to radiant heat shielding, an alternate method for sparsely populated areas consists of local or spot cooling, a method long used for shipboard engine and boiler rooms. Cooled air in this type of installation does not involve air conditioning, but merely washed air delivered from grilles at 80 or 85 F during hottest weather. This method may eliminate the need for increasing the ventilation rate, a step of formidable proportions in a large building.

In colder climates, serious situations often arise regarding inadequate heating and cold drafts. Studies indicate that these are by-products of the summer natural draft ventilation program with its open type buildings that are not easy to close in winter. Where better heating is required, consideration of winter as well as summer aspects frequently favor power ventilators and easily controlled air inlets, by means of which steam saving and uniform heating can be secured.

Layouts of new or modernized plants may benefit directly from ventilating considerations in early conferences. In one case, for example, a more compact building arrangement and a shorter production flow line was made possible by eliminating one line of space-wasting courtyards. Ventilation benefits were retained by use of a forced air supply, obtainable today without ductwork by use of the new fresh air type roof ventilators.

Considerable groundwork should be done with these applications before major projects are submitted to management, because radiation shielding and spot cooling procedure is still far from standardized. Further, various engineers as well as operating personnel have different yardsticks for measuring the end results in heat relief. Again, each plant and department frequently has special conditions that must be taken into account. In spite of these road blocks, this new phase of industrial engineering can valuably contribute to plant economy and increased productivity.

"MODERN A-C — D-C CRANE CONTROL FOR STEEL PLANTS"

by W. R. WICKERHAM and G. E. MATHIAS, Control Engineering Department, Westinghouse Electric Corp., Buffalo, N. Y.

▲ THE load-o-matic alternating current crane hoist control system is a development of the reactor system. In the new system, the motor torque has been arranged to respond principally to the load on the hook, rather than to the speed. The load signal generator or "load detector," is an inductor actuated by an eccentric bearing supporting the hoist rope equalizer sheave. The mechanical deflection resulting from hook load is converted into a proportional electrical signal which is employed in the reactor excitation to coordinate the motor torque with the load.

The system employs unbalanced voltage to modulate the motor torque, as do two other systems in extensive use. The unbalance, however, is variable, and is reduced with increase in load through action of the load detector. The reduction of unbalance with the heavier loads estimates the excessive motor input currents ordinarily associated with this type of control.

Reduced light hook hoisting and lowering speed is controllable between the limits of 20 to 60 per cent normal. The load detector may be adjusted to produce any desired full load lowering speed whatsoever, and thus provide speed-torque characteristics heretofore unattainable with any type of control. The speed may be arranged to decrease with load, and it is proposed that the speed on the first lowering controller point shall decrease from the light hook value of 20 to perhaps 5 per cent at rated load.

Optional features provide that the lowering speed for any load may be slowed to standstill and the load "floated." Incremental hook movements averaging 0.03 in. have been consistently attained on a crane having a normal hook speed of 40 fpm. Limit contacts on the detector can be arranged to operate an overload signal, or to prevent the crane from lifting a dangerous overload.

"COAL AND ORE BRIDGES"

by E. L. BLANKENBEKER, Electrical Engineer, Heyl & Patterson, Inc., Pittsburgh, Pa.

▲ MODERN coal and ore bridges vary in rating from 10 to 22.5 tons as determined by bucket capacity. In practically all cases the machinery is driven by standardized AISE mill type d-c motors. A review of a considerable number of bridges built in the last 10 years indicates that there are only two sizes when considered from the standpoint of motor hp rating applied to the hoist drive. The frame 616 motor or its predecessor has been applied to the dual engine hoist drive on bridges rated at 10 net to 12 gross tons. The frame 618 motor or earlier design of similar rating has been applied to the hoist drive of 15 to 22.5 net ton ratings. The hoisting speed was selected in each case to fit the motor rating to the load.

The paper gives the basis for applying motors to hoist and trolley and bridge drives. Comparison is made of performance obtainable from constant voltage series wound motors and adjustable voltage d-c motors for both hoist and trolley drives. By overvoltage operation from individually regulated d-c generators, the shunt motor can be geared to handle more tonnage than can the constant voltage series motor of the same size.

The selection of motor size for trolley drive is discussed with particular reference to top speed and acceleration as affecting wheel slippage and the operator's reaction. Curves are included, comparing series motors with shunt motors of the same rating to obtain equal performance on trolley travel drive. The sustained acceleration to top speed obtainable with shunt motors results in a lower top speed than with the series motor drive which is desirable from a safety standpoint.

The paper gives a broad outline of control requirements and discusses briefly the drives for the other motions on the bridge. References are given to previously published more detailed papers on this subject.

"CRANE WHEEL TREAD CONTOURS"

by JOHN J. STOLZ, Chief Engineer, The Tool Steel Gear & Pinion Co., Cincinnati, Ohio

▲ SINCE the introduction of taper tread wheels for cranes many years ago, there has been a constant difference of opinions as to which contour is the best. There are in use today all three types, namely, the radius tread, the straight tread, and the taper tread wheels. In discussing the various types with a representative group of operating men from most of the large steel producing areas, the author has tried to secure reasons why certain contours are used.

The information gained generally indicates that more taper tread drive wheels are used; however, there are good reasons pro and con on this subject. It has been found, however, that a quantity of factual information is not available. The use of a certain contour is largely a matter of opinion, based on experience.

This brings up a question—should a committee be formed to study the problem? Such a study would no doubt produce data on wheel life, rail life, crane maintenance, and many other vital points on which we have no basic facts at present.

The Institution of Mechanical Engineers of Britain published an interesting paper in their Proceedings of 1950. The title, "The Effect of Taper Tread Wheels on the Motion of Overhead Cranes." Their conclusions state that the use of taper tread wheels reduced the wear on wheels, rails, and cranes. The wheel life is lengthened by the use of taper wheels as there is no flange contact with the rails. If Britain had made such a study, we in this country should consider the possibilities and advantages to be gained from factual information that can be acquired.

"ROLL TURNING WITH TRACER CONTROLLED LATHE"

by FRANK F. ZIPF, Superintendent Roll Department, Bethlehem Steel Co., Johnstown, Pa.

▲ THIS is perhaps the first time that a paper of this nature has been presented to a meeting of the Association of Iron and Steel Engineers. The author has attempted to briefly describe the development of tracer controls for various machine tools for a better understanding of their application to lathes. The article also gives a brief description of the different types of tracer controls, both electric and hydraulic, and the usefulness of this type machine in roll turning. Steps are also covered in the selection of the proper grade of carbide tools which has made it possible to use this type of machine in the roll turning craft.

A photographic study has been prepared illustrating a complete record of the turning of a pair of two-high rolls for a rail section turned on a tracer lathe. This study shows the hourly machining progress. A comparison is also given showing the time saved on this pair of rolls, as compared to the time for the same rolls had they been turned on a conventional type roll turning lathe.

"OPERATION OF A 12-IN. CONTINUOUS BAR MILL"

by A. H. GRIFFITHS, Superintendent of Rolling Mills, Sheffield Steel Corp., Kansas City, Mo.

▲ IN August 1948, the Kansas City Division of Sheffield Steel Corp. started operating a new type 12-in. continuous bar mill. Four common billet sizes are used in the mill—2, 2¾, 3⅝ and 4 in. These are heated in a continuous type furnace 32 ft wide x 50 ft long, with a rating of 60 tons per hr. Furnace can heat billets up to 30 ft in length and can be fired by gas or oil.

The mill consists of twelve stands, plus three stands of vertical edging rolls, making a total of fifteen stands. The roughing and intermediate stands are located in a straight line with No. 9 stand located 10½ ft to the left

of the roughing and intermediate train, and stands 10, 11 and 12 situated 10½ ft to the left of No. 9 stand, thus allowing the use of two 180 degree repeaters. The rolls used in stands 1, 2, and 3 of the roughing train are 18 in. in diam. by 36 in. in length, the 5-stand intermediate rolls are 14 in. in diam. by 32 in. in length, and the finishing rolls are 13 in. in diam. and 24 in. in length. The rolls used in No. 1 and No. 2 edging stands are 13 in. in diam. by 7 in. in length, and No. 3 edging stand is 15 in. in diam. by 3½ in. long. The rolls are driven by individual variable speed motors with the exception of No. 1 and 2 stands and No. 4 and 5 stands. These are coupled together by a motor for each set of stands. No. 1 and No. 2 stands are driven by a 500-hp motor with an 800-hp motor driving No. 4 and No. 5 stands. The remaining stands are driven with their own individual 500-hp motors. No. 1 edger is driven by a 150-hp, No. 2 by a 100-hp, and No. 3 by a 100-hp motor.

The finished product from the mill can be either coiled or run onto the cooling bed depending on the orders.

In addition to describing the mill, the author describes many of the operating problems which had to be solved in order to get the best and most efficient operation out of the mill. Among these problems were developing methods for mechanically repeating angles, an item which was not incorporated in the original design. The mill has been a good producer and during May 1951, it rolled 11,779 net tons consisting of 35 sizes of angles in 267 operating hours. Rated average of production was 3.09 lb per ft.

"LUBRICATION OF WIRE ROPE"

by C. H. LAYTON, Assistant Chief Rope Engineer, Hazard Wire Rope Division & American Cable Division, American Chain & Cable Co., Inc., Wilkes-Barre, Pa.

▲ THE days are gone when manufacturers and most wire rope users were content to apply just any available grease or lubricant to wire rope and consider the matter closed. Considerable study has been made in the past years regarding the value of wire rope lubrication and the proper type to be applied. Such studies are continuing and will possibly continue to be made as long as wire rope is used in industry. It is to be agreed that the problem of proper lubrication is complex and extremely interesting and covers considerable scope within the manufacturer's plant.

Each wire rope manufacturer uses what, in his opinion, is the most suitable for the service. In setting up and introducing any proper lubrication practice, it is first necessary to analyze existing conditions, whether on an old or new installation, and to institute a careful survey of the rope in service or a discarded sample to determine the type of deterioration against which to guard. This kind of approach is necessary because in all cases the safety of men, materials and continued production depend on the wire rope which has been thoroughly lubricated and properly maintained.

Anyone familiar with lubrication of machinery, and wire rope or cable may well be compared to a working machine, can appreciate the frictional forces set up and the type of deterioration which can take place if bearing points are not properly lubricated. There can be no doubt that the need for an efficient maintenance program, with regard to treating wire rope with some proven compound, is present and required to insure safety of operation and the ultimate in service. In the present world emergency, the subject of wire rope lubrication should be of greatest interest to wire rope users since improved rope performance results in increased production and efficient plant operation.

"QUALITY CONTROL OF LUBRICANTS"

by CARLYLE R. BURTON, Superintendent of Maintenance, Hibbing-Chisholm District, Oliver Iron Mining Co., Hibbing, Minn.

▲ THE mining of iron ore requires a variety of heavy duty equipment which offers many complicated lubrication problems. In order to insure proper lubrication of these pieces of equipment, a preventive maintenance program is being carried on. The quality control of lubricants is a part of this program and consists of the analysis of new fuels and of new and used lubricating oils, greases, water, etc. By its analysis, the oil laboratory keeps to a minimum the number of lubricating products required and controls the lubrication of some 265 odd pieces of engine powered mining equipment.

By simplified analysis the oil laboratory tests over 100 samples per day, determining each day whether any oils need renewing or filtering. A check on the viscosity of the oil and the per cent solids in the oil determines the action of the oil shop laboratory.

The quality control of lubricants has allowed volume purchasing savings in lubricants, decreased lubricating oil consumption, decreased engine wear and increased mine production due to less equipment "down" time.

"SPRAY LUBRICATION OF OPEN GEARS"

by JOSEPH A. RIGBY, Vice President, Engineering — Sales, The Brooks Oil Co., Pittsburgh, Pa.

▲ OPEN gears are diminishing in general use and supplanted insofar as possible with enclosed gears or direct drives in new installations. Regardless of these facts, the magnitude of quantity in use, continuation of service for many future years and the necessity for continued use with certain types of new equipment establishes the factor of lubrication to exist and continue as one of importance.

Lubricants for satisfactory service have probably been used since the origination of metal gears. Gradual increase in loads, speeds, improvement in gear design and heavy industrial development have in turn presented a problem to lubricant manufacturers. This problem has been progressively solved with submission of lubricants for satisfactory service and a gradual change from animal and vegetable fats to compounds of the same, petroleum compound of resinous materials, residual products, extreme pressure greases and

solvent cutback materials which are readily accepted today.

In the beginning, applications were probably made in a crude manner by swabbing with fats or possibly dropping gobs of the lubricants on the gears while at rest or in motion. Dipping and dripping methods have also been used, and there was then evolution to lubricants almost solid in nature and which required heating for application. This permitted application by pouring from a container to establish a shielding coating on the gears by solidification in cooling. With this method, protection against wear was reasonably well developed but with a buildup of lubricant to produce high frictional drag, excessive throw off and high cost clean-up and disposal of labor.

Extreme pressure greases and solvent cut-back lubricants with unusual adhesiveness, thin film and extremely high film strength, met with great favor and were quickly adopted. From this development, the part of lubricant users, lubricant manufacturers and lubricant appliance manufacturers was that of better methods for application. This involved improved distribution on gear teeth, more economical consumption of lubricants, handling of lubricants without contamination, negligible heating requirements, reduction of throw off and drippage, safe working conditions for workmen and that of progressive and aggressive action to keep abreast with engineering and industrial advancements.

Supporting the necessity of improved lubricant applications has been the accomplishments of the lubricant appliance manufacturers in development and submission of practical equipment to succesfully and economically spray open gear lubricants. These are of various types, but provide open gears with logical, safe and economical lubrication.

"OPERATIVE RESULTS OF ONE-WAY FIRED RECUPERATIVE SOAKING PITS"

by JAS. C. STAMM, JR., Field Engineer, Fuel Department and E. H. CAUGER, Chief Combustion Engineer, Wheeling Steel Corp., Steubenville, Ohio

▲ THIS paper includes sections on: 1. need for new pits and reasons for selection of one-way fired pits, 2. description of the pits; 3. a description of their controls including temperature, pit pressure by air jet principle, air-fuel ratio, proper atmosphere, and 4. results in tons per hour; tons/hr/1000 sq ft hearth area; and Btu per ton from stand-point of: a. pour to strip time; b. size ingots; c. number ingots each size; d. tons per charge and results from stand-point of improvement of quality—including evenness of heating and lack of washing and improved surface; and 5. maintenance problems of equipment, bottom making, rebuild.

Tables are included on: 1. results from pour to strip time; 2. results by size of ingots charged; 3. results by number charged of each mould size; 4. results by tons per charge; 5. per cent of slabs scarfed over period before, during and after new pit installations; 6. ingot sizes and weights; and 7. temperatures of ingots as pulled and slabs after blooming.

Graphs are included on: 1. results from pour to strip time; 2. results from size of ingots; 3. results from number charged of each mold size; 4. results from tons per charge; and 5. results from per cent of slabs scarfed. Diagrams are included of: 1. common method of charging different size ingots with their proper spacing; and 2. schematic diagram of control and pit layout.

Pictures of various features and processes are included such as: 1. ingot being drawn from hot pit; 2. ingot being charged; 3. a view of the panel houses and the combustion fan; 4. a close-up of one of the master control sections of the panel; 5. the Hazen recuperator; 6. the refractory recuperator; 7. the basement tunnel with the clean-out setup; 8. a view of the air header, jet damper control cylinder, etc., in the basement; and 9. a close-up of the controls—rear of panel.

"LATEST DEVELOPMENTS IN EXTRUSION OF METALS"

by ERWIN LOEWY, President, Loewy Rolling Mill Division, and Hydropress, Inc., New York, N. Y.

▲ CONFINED almost exclusively to the working of lead during its early stages of development and, later, spreading to the copper and light metals industry, the extrusion process has grown to the ranks of the foremost methods for converting metals into wrought shapes. The advantages of this process have resulted in efforts being directed towards the development of techniques for extruding high alloy steels, stainless steel, nickel alloys and other high strength special alloys.

This paper deals with the problems involved and the developments in hot extrusion of these high temperature materials, commencing in 1926 with the extrusion at about 1900 F of cupro-nickel. The first hot extrusion of high temperature metals on a production basis in this country was performed at the Huntington works of the International Nickel Co. at West Virginia on a 4,000-ton horizontal extrusion press having an independent piercing arrangement. This press was used to extrude solid billets of monel, inconel, and nickel ranging in diameter from 7-12 in. into tubes of 3-8 in. OD x ¼ in.—⅝ in. wall thickness. The tools were made of hot work steels having various amounts of tungsten and chromium.

An important factor in the hot extrusion process is lubrication since not only the ability to extrude but the quality of the product and the durability of the tools are dependent upon it. This is one of the major problems with which we have had to deal and for which we have to find a satisfactory solution. The steel industry in particular was greatly encouraged in learning of the highly satisfactory results obtained by the use of a glass composition as a lubricant for hot extrusions of steels and other high temperature alloy billets.

Another contribution of importance in the hot extrusion process is salt bath heating. In addition to the salt acting as a lubricant, it performs the very important function of providing a scale-free surface and of shortening the heating time of the billets prior to extrusion.

Successful experiments in hot extrusions have produced hollow steel propeller blades of chrome-nickel-

molybdenum steel far superior in quality and physical properties to those made by welding and brazing. Experiments are now being carried out on the extrusion of gun tubes of several different sizes made from nickel-chromium-molybdenum steels at temperatures of about 2300 F.

Other developments include the extrusion of stainless steel tubing; of multiple hole aluminum tubes from solid billets; of billets made from 16-25-6 Timken alloy, and the extrusion of titanium bar and rods.

The expanding application of hot extrusion of high temperature metals and alloys, and the increasing complexity of shapes which can more desirably be produced by extrusion, make it evident that the need has arisen for extrusion presses larger than any that have previously been built in this country.

Under a design at the present time is a 25,000-ton extrusion press. This press will be capable of extruding at one time two spars of an airplane wing. In addition to extruding complete airplane parts, it is planned to use the 25,000-ton extrusion press to pre hot work cast billets priors to forging them on a 75,000-ton forging press. Through the use of these presses, tremendous savings in manpower, machine time, and materials will be effected. Equally important, the parts thus produced will have better physical and metallurgical properties and will permit marked reductions in the weight of our planes.

The developments in extrusion and extrusion presses not only warrant the serious consideration of these presses by the steel and metals industry in general as an economical, and in some cases the only, means of producing various shapes and profiles, but they also present an incentive to the industry for the development and improvement of hot working steels used as tools in the extrusion of the high temperature materials.

"PHOSPHATE COATINGS AS LUBRICANTS IN THE SEVERE COLD-FORMING OF METALS"

Part I — General Description

by S. SPRING, Group Leader, Research and Development Division, Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.

▲ *PART I — General Description* — The phosphate coating may be considered as a "fixed pigment" acting to separate contacting metallic surfaces; it is used in conjunction with an organic lubricant such as a soap or a fat emulsion.

A primary reason for the success of phosphate coatings in this application is the good adherence of the phosphate coating to the metal, which permits it to survive large shearing stresses at the die.

This adherence is a critical factor and is determined by surface pre-treatment and the chemical composition of the phosphating bath. Some characteristics of the phosphate coating pertinent to its use in cold forming are discussed, together with a photograph of the coating before and after drawing. In addition, a chemical rinse after phosphating is instrumental in improving the adherence of the lubricant to the phosphate coating. The process of formation of a phosphate coating is discussed as well as the preparation and control of a phosphating bath for use in the cold forming of steel.

Part II — Application

by DR. LUDWIG K. SCHUSTER, Chief Chemist, Heintz Manufacturing Co., Philadelphia, Pa.

▲ *Part II—Application*—Phosphate coatings as an aid to facilitate cold-forming of metals were used first in Germany. In the year 1934 Dr. Fritz Singer applied for a patent to phosphatize articles and subsequently subject them to cold-forming operations. Phosphate coatings represent just one type of the numerous salt coatings, chemically or physically produced on metal surfaces, to aid in severe ironing and drawing operations. Such coatings are, for instance, lime, borax or oxide films. The advantages of phosphate coatings compared with these coatings are: uniform composition and constant physical properties, produced in baths, which can be controlled easily. The coatings can be tailored for each specific cold-forming operation. They possess enhanced separation power, satisfactory anti-welding properties, and excellent "carrying through" through the dies under high pressure.

Application of phosphatizing is limited to those metals which are attacked considerably by dilute phosphoric acid at elevated temperatures; these metals include straight carbon steel, low alloy steel, aluminum and its alloys, and zinc and zinc alloys. Stainless steel cannot be phosphatized.

The following advantages of phosphatizing for cold-forming operations open a wide field for application in the steel industry: enhanced die-life; higher drawing speeds; greater single reduction; elimination of some annealing operations; prevention of scoring, galling and pickup; smooth finish and enhanced corrosion resistance. Typical fields of application are: wire drawing; tube drawing; stamping; deep drawing; ironing and cold extrusion. These fields of application are discussed in details with particular emphasis on the advantages offered by phosphatizing.

"RECTIFIER APPLICATION FOR STEEL MILL DRIVES"

by GEORGE B. SCHEER, Chief Consulting Electrical Engineer, Kaiser Engineers, Division of Kaiser Industries, Inc., Oakland, Calif.

▲ THIS paper briefly discusses the original method of obtaining constant potential d-c power using motor generator sets. The reasons for the subsequent use, two years later, of rectifiers for obtaining the d-c power are reviewed in more detail. A brief discussion of both the theoretical and operating advantages and disadvantages is made and, in particular, a comparison is given showing the relative initial use of materials and the operating cost from both an efficiency, operating and maintenance standpoint.

The paper then discusses the use of rectifiers for furnishing the power to drive a merchant mill. The mill at Fontana has a 2600-kw rectifier and a buck boost generator working in conjunction with this rectifier. This mill was installed in 1946 and was one of the earliest mills to depend 100 per cent on the use of a rectifier. The newest installation, an 86-in. 4-stand hot strip mill, driven by three 5000-hp motors and one 3500-hp motor with power supplied by two 5000-kw rectifiers with water cooled pryanol transformers, is discussed. Included in the paper are operating cost, space saving, material, effect on motor room ventilating equipment, power factor, impact loading, speed control, acceleration and deceleration.

Although Fontana has probably a greater percentage of rectifier equipment than any mill in the country, particular emphasis is made regarding its limitations and the necessity to use caution in the application of rectifier drives.

"CONTROL OF DEMAND AND POWER FACTOR ON ELECTRIC ARC FURNACES"

by H. G. HEATH, Electrical Engineer, Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa.

▲ THE control of demand and power factor as applying to the electric arc furnace has been a pertinent problem since about 1920. A number of devices were devised, patented and otherwise applied to the problem, with a number of disadvantages. The control of demand and power factor with the multiplicity of differences in the power rate set up, made it necessary to give specific consideration to each furnace installation.

Aside from the desired production rate, it is necessary to give consideration to the demand from the standpoint of obtaining the most economical power billing. A power factor of 85 per cent indicates a total impedance of 52½ per cent with reference to the primary circuit. From the record of many, many furnace installations, it is apparent that the relation of total impedance to power factor is not well understood.

To hold or limit the demand to obtain the minimum power company billing and to obtain the most efficient operation of the furnace, the use of a device or combination of devices is necessary. With due consideration, a good power factor average will be obtained.

Some devices operate on an impulse basis from a contact equipped watthour meter and operate to reduce load in case the demand setting is being exceeded. Some disadvantages are inherent in that the load might be cut too often during a specific demand period, or advantage might not be taken of any delay during the period.

Within the past two years, a device or method of fixing the demand for several furnace voltages directly as a function of the electrode positioning regulator has been applied. This demand value has been set up on the basis of the efficient current value and is independent of any adjustment by the furnace operator. Some modifications have been applied to this system. Where a number of furnaces are involved in one plant, other considerations such as staggering the load to limit the maximum demand are in order.

"A-C POWER DISTRIBUTION IN STEEL MILLS"

by D. L. BEEMAN, Manager, Industrial Power Division, General Electric Co., Schenectady, N. Y.

▲ THERE have been great strides made in the design of a-c power systems in general, particularly for steel mills. The progress has been along two lines:

1. Improved system engineering.
2. Improved equipment for the systems.

In the field of system engineering, the most notable advances have been the introduction of the load center distribution system for both high and low voltages, the trend toward higher voltages, increased use of system neutral grounding, improved short-circuit protection, etc. The load center system approach is based on serving each load area by its own substation or substations. This provides economy at all voltages because the power is taken to the load center at higher voltage and there stepped down to utilization voltage. By having smaller substations for utilization areas, the cost of the substation and switchgear for that area is reduced. Many steel mills are now using 11.5 kv or 13.8 kv instead of 6.9 kv where power has to be transmitted at these voltages in substantial quantities and for relatively long distances. In even larger mills, higher voltages like 22 kv, 34.5 kv, or 69 kv, are used for the basic transmission of voltage from the source point to the load centers. Short-circuit protection, particularly in low-voltage systems, is receiving more and more consideration. Grounding the neutral of all system voltages has shown marked increase in service reliability and marked decreases in system maintenance costs.

These and many other system items of interest to the steel mill engineer are discussed in this paper. In the field of equipment improvements there are, of course, improvements in metal-clad switchgear which have been made over a period of years, the introduction of factory assembled unit substations, metal-enclosed plug-in bus duct, improved low-voltage circuit breakers, switches and fuses, etc. These are described briefly and outlined as to how they fit into the modern system.

"THE AXIAL COMPRESSOR FOR BLAST FURNACE BLOWING"

by W. O. LOWELL, Blower and Condenser Section, Mechanical Power Department, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

▲ FOR blast furnace blowing service, an overall efficiency improvement of 14 to 16 per cent can be realized with an axial compressor unit over a comparable centrifugal blower unit in the larger ratings. This improved operating economy translated into dollars saved on the basis of a unit rated at 110,000 cfm at 30 psig means annual savings of over $20,000.00 per unit in the cost of steam alone. When the annual cost of steam power alone for a centrifugal unit of this size may reach $190,000.00, air cannot be considered "free" but ap-

proaches the status of an expensive ingredient in the operation of large blast furnaces.

The axial compressor is by no means a newcomer to American industry. In the experience of the writer's company, units totalling more than 2,250,000 cfm and utilizing over 250,000 hp have been installed and cover a design and operating experience of 15 years. These units vary in size from 9,000 to 860,000 cfm and serve the petroleum refining, aircraft testing, railroad and gas utility fields.

In comparison with the standard centrifugal blast furnace blower, the axial compressor will not require the development of a new operating procedure since in operation it closely follows the same overall range of pressure vs speed as the centrifugal. Neither will the narrower stable operating range of the axial compressor create a problem since the constant volume speed control for the turbine also includes an automatic blow-off valve with a silencer for unusual low volume operating conditions. Other characteristics of the axial compressor show that this type of unit offers definite advantages over the centrifugal for blast furnace service.

The design of axial compressors together with the performance record they have built up now furnishes adequate evidence that they deserve serious consideration in any blast furnace installation calling for large volumes of air.

"ROLLING OF THIN STRIP"

by M. D. STONE, Manager of Development, United Engineering & Foundry Co., Pittsburgh, Pa.

▲ THIS paper deals with the theory and practice of the cold rolling of thin strip, as influenced by rolling mill design, particularly adapted for such work. Although aluminum foil rolling has been practiced for decades now, going down to 0.0003 in. and less in widths of 24 in. and greater—which is still the ultimate in commercial rolling of thin strip—the problem of producing stainless steel strip ten times as thick is very much more difficult.

The importance of such factors as work roll diameters, type of material being rolled as affected by work hardening characteristics, front and back tension, rolling lubricants, roll flattening, type of mill drive, etc., are covered in some detail. Descriptions of several mills designed especially for such practice are given.

"FLASH WELDING AND HIGH SPEED COLD REDUCTION OF STRIP STEEL FOR TIN PLATE"

by JOHN WARGO, Assistant Tin Plate Metallurgist, and RAY C. BRUNNER, Development Engineer, Jones & Laughlin Steel Corp., Aliquippa, Pa.

▲ THE economic value of a high speed mill can only be realized when such a mill is able to roll consistently a product of commercial quality at or near its rated capacity. Excessive delay time or too frequent operation at speeds below those for which the mill was developed and powered, defeats the purpose of high speed rolling, and the production when measured quantitatively is comparable to slower conventional mills.

One of the disadvantages in operating a high speed mill is the necessity (because of size limitations in the steel making and rolling prior to pickling) of entering into the mill build-up coils containing several welds. Reduction of speed when the welds are rolled, or weld breakage with the possibility of damage to work rolls which might require their removal from one or more stands, can be a serious detriment in attaining the mill's production potential.

The ability to weld strip steel and roll the welds at speed on the cold mill has been and continues to be a very important requirement for successful mill performance. Flash butt welding of hot bands by the electrical resistance method is performed at the Aliquippa works by a hydraulic type machine specifically designed for this purpose. Since the strip is not subject to any considerable variations in cross-sectional area or chemistry, the same general welding practice is maintained on all material welded. Strict adherence to a servicing schedule, particularly in respect to welding dies, has been found necessary for producing satisfactory welds. A sound weld if improperly trimmed is not suitable for cold rolling. To obtain a consistently uniform trim, the automatic weld flash trimmer has been altered from its original design.

Any operational improvement on the cold mill is undoubtedly reflected in improved weld rollability, although this is difficult to evaluate objectively. In this respect the development and use on the 42 in. tandem mill at Aliquippa of the present method for applying the palm oil and water mixture to the strip, and the water system for cooling the rolls and strip have been important contributions.

"THE APPLICATION OF BENTONE LUBRICANTS TO THE STEEL INDUSTRY"

by D. H. COMPONDU, Product Engineer, The Warren Refining & Chemical Co., Cleveland, Ohio

▲ BENTONE greases had their inception some ten years ago at the Mellon Institute for Industrial Research. The National Lead Co., through fellowships, developed the various bentones and since has made them available to the lubrication grease manufacturers.

The name bentone, as it is used in the lubrication industry, is not to be confused with bentonite clay. A great deal of time could be consumed in defining the complete process of its manufacture, but since we are primarily concerned with its function as a lubricant, we need not dwell on the manufacturing phase at this time. For our purpose, it will suffice to describe bentone by saying that it is the reaction product of montmorillonite and various organic cations which, when dispersed in oil, forms a completely stable gel, physical in nature, that does not depend on the maintenance of a matrix to hold the oil. As a result, the characteristics of the grease are those of the oil but, in addition, possess superior adhesive properties and ability to lubricate equally well at extremely high or low temperatures.

Reports on the use of bentone lubricants in steel mill applications have proven beyond question that lubrication problems have been minimized, and that bentone grease is the first truly multi-purpose lubricant yet placed upon the market. These reports on the superiority of bentone greases over the conventional soap base greases are substantiated by a number of case histories on specific steel mill applications, e.g., sintering conveyors, annealing ovens, electric motor bearings, overhead crane bearings, etc.

Bentone greases in application have proven that lubrication problems can be minimized by their use, and that in most instances they will outlast the conventional greases by two to four times. Bentone greases are manufactured in most NLGI grades, thus providing a lubricant of the proper grade for practically any type of application where grease would normally be used. In addition, with the use of some of the diesters as a base oil, it is possible to provide a bentone grease that will provide satisfactory lubrication at temperatures as low as –60 to –70 F.

"STANDARDIZATION IN THE LUBRICATION DEPARTMENT"

by J. D. LYKINS, Chief Lubrication Engineer, Wheeling Steel Corp., Wheeling, W. Va.

▲ FOR one to realize the value of standardization, he has only to take a cross-section of industry and government departments and study what has been done in this field in the past few years, or take what the AISE is doing. They have set up committees to study d-c mill motor standards, standards for machine surface finishes, crane wire standards and many others. In other words, standardization is of prime importance to the steel industry.

Wheeling Steel Corp. realized the value of standardization in the lubrication department shortly after this department was established in 1939. The first concern was standardization of lubricants in all the plants. It was not uncommon to go into a plant or even a department and find two or three similar products being used to lubricate similar equipment. Since the program for standardization was started, the number of products being used has been reduced approximately 75 per cent. In one plant alone, there were 147 different products being used in 1940. This number has been reduced to 24 as of August 1, 1951.

Standardization of lubricants is not the only concern of the lubrication engineer. He is also concerned with standardization of equipment such as grease fittings, oil cups, centralized lubricating systems, pumps, valves, sprays, seals, bearings, etc.

In one plant, to lubricate a series of machines, there were three different types of oil cups being used. The capacity of one cup being such that it had to be filled every four hours. Another cup had a capacity for twelve hours. By standardizing on the greater capacity cup, it was possible for the oiler to fill the cups every eight instead of every four hours with ample oil supply left for safety. There being three hundred cups to fill, this left time for the oiler to be assigned other equipment to care for.

Standardization will affect the following: (1) Inventories—will reduce required storage space and ease inventories; (2) Purchasing—eases the problem of purchasing, permits buying to specifications and in larger quantities effecting savings in unit costs; (3) Simplification—reduces the chance of the wrong product being used in the wrong place; (4) Turnover—permits faster turnover of products which reduces chances of deterioration in storage; and (5) Training—eases the training of new personnel for maintenance of equipment and lubrication.

"RECONDITIONING AIR FILTER OILS"

by GEORGE FINDLAY, Lubrication Engineer, Republic Steel Corp., Buffalo, N. Y.

▲ THE steel industry, until recently, has attempted only to a very limited extent to filter air used in its operations. In effect, the only general approach to the use of filtered air throughout the industry was confined more or less to cooling large critical motors, motor generator sets and motor rooms.

However, due to the ever increasing demand for steel products, considerable thought and study have been given to find what methods of preventive maintenance might be used to permit a minimum of delay or down time to prime movers such as turbo blowers. It is for use with turbo blowing equipment that this program of air filter oil reconditioning has been developed.

Where periodic impeller replacement or repair intervals can be extended to any major extent, the attendant savings offered will very quickly amortize the initial investment of the filtering equipment. The savings involved include reduction in abrasive wear of impeller blading, lessening of down time for repair and replacement of blading, etc.

Several different types of air filters are employed in the steel industry, with those of the travelling screen design predominating where blast furnace blowing equipment is involved. The primary purpose of the air filter in this case, is that of removing only the solids which will tend to abrade the blading.

Experience has indicated that to be effective, the air filtering equipment must be maintained on a continuous operating cycle. This in turn demands the installation of an automatic auxiliary oil reconditioning system in order to maintain the oil in the screen reservoirs within acceptable limits of clarity. Changes to existing screen reservoir design would simplify the installation and increase the efficiency of the oil reconditioning unit.

This type of reconditioning system is found to maintain the flash point characteristics of a mineral oil, as used in the air filter reservoirs within the limits of safe operation. After investigation of the nonflammable fluids which are sometimes recommended for this service, it was deemed advisable to accept the possible fire hazard associated with the use of mineral oil in preference to the toxicity hazards involved with the use of the former.

Lubrication and Maintenance of Bearings

By L. E. LOVITT
Socony-Vacuum Oil Co., Inc.
Pittsburgh, Pa.

. . . . lubrication is an important part of maintenance which can reduce operating and maintenance costs . . . .

▲ CONSIDERABLE progress has been made in bearing design since the days of the old hand mills. Originally all roll neck bearings were the plain segment type, either of brass, bronze or babbitt, and later the so-called composition bearings were introduced. Many bearings of this type are still in use but most of the modern mills are equipped with anti-friction or oil film type bearings. Maintenance requirements on the metal segment bearings are high, due principally to high temperature, inadequate lubrication and mill load conditions. Mills, where these bearings are now used, are usually flooded with water which controls the temperature within reasonable limits. However, bearing temperatures may be influenced by the manner in which the thrust face is lubricated. With the exception of the composition type bearings, the segment type plain bearings were designed for block grease lubrication. In recent years, however, many of these bearings have been redesigned for lubrication with a soft grease applied to the bearings from a pressure grease system. In the places where the lubrication of these bearings has been converted over from block grease to a soft grease, it has been through the efforts of the maintenance department or the lubrication engineer with the cooperation of the maintenance men. Nearly every installation is different, thus requiring rather close study of the bearing and assembly in the mill to determine where to put the grooves serving as grease reservoirs and how to drill the bearing caps for a connection to the grease system without weakening the bearing mechanically or reducing the effective bearing area. Also, it is important to provide a positive grease feed to the thrust face. This may be accomplished by bleeding off a small amount of the grease supplied to the bearing itself or by a separate feed. Often after the first attempt at lubricating bearings in this way, certain modifications have to be made to obtain better grease distribution. This, therefore, is really a maintenance job, and its success depends upon the desire of those handling that work to get the best results which, in the end, will reduce the amount of maintenance necessary.

Scale and dirt washed onto the bottom roll neck bearing will not only accelerate bearing wear but will interfere with the lubrication. This has been overcome in a number of places by the design and installation of scale guards. Scale guards also require special consideration because such a device, to be satisfactory, must be simple in design and so installed that they can be easily removed and replaced without damage during roll changes and also suffer no damage at any roll position while the mill is in operation.

Unlike the plain segment type bearings, anti-friction and oil film type bearings are precision bearings designed for positive lubrication. Therefore, the automatic or semi-automatic systems supplying lubricant to the bearings should be considered as part of the bearing assembly and, as such, receive as much maintenance attention as the bearings themselves.

Anti-friction bearing maintenance must naturally justify itself economically. In some cases, bearing maintenance only warrants periodic inspection, when certain equipment is out of service, and replacing the worn or damaged bearings, if not suitable for further service. In other cases, the cost of the bearings justifies complete overhaul at regular intervals. These bearings, which are usually grease lubricated, must be cleaned when brought into the shop for overhaul. There are many different ways and methods of cleaning. Kerosene, torch oil or other types of petroleum or non-petroleum solvents are used. The actual cleaning ranges from the crude method of hand swabbing to more elaborate degreasing systems. However, the method and solvent used should be such that the men do not have to keep their hands in the solvent or work in an atmosphere contaminated with solvent fumes.

Bearing cleaning systems where the parts are put in a closed tank, and the solvent sprayed onto them at high velocity or violently agitated, require practically

no physical contact with the solvent. However, at least two tanks are usually necessary, the first tank to dissolve most of the grease and the second tank for the final cleaning to remove all traces of dirt and grease. Other methods employing a water soluble or emulsifiable solvent cleaner are used. Such methods are becoming more popular. The bearings and chocks are submerged in the cleaner, heated to about 140 F for a few hours, and then flushed off with water, removing all of the grease and dirt. After cleaning, all parts are disassembled for complete inspection and overhaul. There is usually enough residual oil or grease film left on the bearings to prevent rusting between the time the bearings are cleaned and repair work is started. This method of cleaning has the advantage of leaving a clean surface which does not have to be wiped for visual inspection.

The majority of anti-friction bearing troubles seem to result from either (1) fatigue failures, (2) foreign material contamination of the lubricant, (3) corrosion, or (4) inadequate lubrication. Also, there is a remote possibility of bearing troubles or failures from electrolysis.

It is important, therefore, that bearing inspections be made by men qualified to recognize the various types of failures and, when recognized, steps should be taken to correct or eliminate the cause. The tendency usually is to classify all bearing failures or troubles as lubrication failures. Actually, however, lubrication failures are infrequent. Probably the most prevalent lubrication failure observed is metal pickup on the ends of the rollers. The ends of the rollers are in sliding contact with the flanges of the inner race. Thrust loads on the bearing will force certain rollers against the flange with sufficient pressure so that momentary welding occurs. The proper type of grease will prevent or minimize the tendency for the welding action. Grease distribution within the bearing plays an important part in correcting metal pick-up. Stiff greases tend to channel in recesses outside of the active bearing area so that at times the bearings may operate with little or no grease on the rollers or races. Greases which are unstable either from the standpoint of oil separation or oxidation will produce the same effect as a stiff grease by channelling in the bearing recesses.

Grease lubricated anti-friction bearings on roll necks operate at fairly high temperatures; consequently, a grease suitable for this service must be one that will not become fluid at the operating temperature within the bearing. In many cases, the roll neck bearings are subject to water contamination; consequently, the grease must not be soluble in water.

In general, anti-friction bearings are not keyed to the roll neck; as a result, the inner race has a tendency to creep on the neck. It is, therefore, important to provide positive lubrication on the roll neck under the inner race. In practically all bearing installations, spacers are provided in the bearing assembly with regularly spaced grooves in them which permit grease from the bearing to be forced down onto the roll neck. Also, when bearings are installed on the roll, the neck is coated with a generous supply of grease which is usually sufficient to protect work roll necks; however, on back-up rolls of four-high mills, the rolls are changed less frequently. On slow speed stands, the initial application, plus the grease fed down from the bearings, will protect the roll neck. On high speed mills, it appears that no grease is fed from the bearing. This is probably due to centrifugal force which prevents grease from the bearing reaching the roll neck. To overcome this, some installations have been made where the rolls are drilled axially at the center with radial holes connected to it under each inner race. The axial hole is connected to the grease system through a rotary or swivel joint, thus giving a positive grease feed to the neck under the inner race.

Wear on the neck from the inner race creep will eventually produce irregularities which may cause bearing distortion. Such distortion will accelerate certain fatigue failures. Reconditioning roll necks is an expensive maintenance operation and anything done to minimize or prevent it will improve maintenance conditions.

Foreign material contaminating the grease and allowed to accumulate will cause excessive wear. It is difficult to distinguish wear from this cause with that which might result from inadequate lubrication. However, when wear resulting from dirt contamination occurs, the worn surfaces are polished, the degree of which will depend upon the fineness of the contaminating material, while the wear resulting from inadequate lubrication will not be uniform, as a rule.

Important in providing adequate lubrication are the systems supplying the grease to the bearings. Centralized pressure grease systems either automatically or manually operated have replaced the hand gun application almost completely. Such systems permit mill lubrication during operation and at more frequent intervals. The grease systems are in continuous operation while the mill is in operation. There are a number of different types of systems, all performing the same function — that of supplying a small amount of grease at regular intervals to each and every bearing. The method of performing this function differs with each type of system, and all systems used have merit. However, to obtain the desired results, these systems must be kept free from mechanical trouble. In most mills the problems of lubrication, which include not only the handling of lubricants themselves but the method of application, are sufficiently numerous as to warrant a separate organization within the maintenance department to handle them. If organized and staffed properly, this organization will have among its several responsibilities that of inspecting and repairing centralized grease systems. The most common trouble with a grease system results from broken or damaged feeder lines. These usually can be repaired on the spot.

Troubles with grease systems resulting from clogged feeders and valves, dirt in the pumps and air bound systems require fairly well trained personnel to locate and correct.

Pumping pressures developed in any particular system will remain uniformly constant unless there is some obstruction in the main system itself. These pressures, therefore, will indicate whether the system is operating properly or trouble is developing. Some mills have installed recording meters to keep a constant record of the system pressure. Obstructions in the system may be dirt and scale or hard materials resulting from grease separation in the system. The latter has been greatly minimized by the quality of the grease now being supplied to the industry. Dirt and scale, however, are

constant problems in any mill. Usually dirt and scale, which contaminate the grease in a system, get in when grease is pumped into the system reservoir. Pumping the grease from the drum through an edge type or fine screen filter into the system reservoir will keep the grease in the system clean and insure better system operation. At least one of the popular grease systems has included such a filter in their assembly as part of the main unit.

Any grease system will cease to function properly if the lines become contaminated with air. Air, being compressible, will act as a cushion which the pump is acting against, thus reducing the grease flow ahead of the air pocket. Systems may become so air bound that (in automatic systems) it becomes impossible to build up sufficient pressure at the reversing valve to operate it. Consequently the system will operate continuously with little or no grease being pumped into the bearings, unless a time limit switch is incorporated as part of the system control. If the limit switch shuts the system off, it will not start again. To correct this condition, it is necessary to completely purge the main grease lines of air, which requires almost constant attention and considerable time, especially in systems where the lines are long.

The advantages to be gained from automatic grease systems can only be realized by proper and consistent maintenance. A number of mills have enlarged the lubrication supervision to include repair shops and equipment to overhaul valves, pumps and other component parts of grease systems. The repair men will replace any part of the system not operating properly with new or reconditioned parts, and then bring the replaced parts into the repair shop where they can be completely reconditioned for re-use.

Oil film bearings used on roll necks are essentially sleeve type bearings designed to carry much higher loads than conventionally designed bearings. There are but two principal types of these bearings used in this country; namely, the Morgoil bearing and the Mesta bearing (sometimes referred to as the Iverson bearing or Mesta Iverson bearing). It should be emphasized that lubrication plays a most important part in the proper functioning of these bearings. The bearings are so constructed that a positive and continuous oil film is formed and maintained at all times when the bearing is in operation. The oil, used to lubricate the bearing, also circulates through it in a manner to maintain a uniform bearing temperature.

The two types of oil film bearings mentioned above are radically different in design, construction and assembly, but the fundamental principle of lubrication and cooling are similar. Oil reservoirs or pockets are machined into the bearing bushing at either side of the pressure area. These pockets are chamfered toward the pressure area so as to start the formation of an oil wedge as the journal starts to rotate. Oil pressures are so regulated that the pocket or reservoir is always full of oil, thus eliminating any change or discontinuity of the oil film.

It is seldom, if ever, that these bearings show any evidence of failures from a lubrication standpoint if the oil used is of the proper grade and body and no failure of oil supply occurs. There are, however, certain operating and assembly factors which will affect the proper functioning of the oil. Again, as in the case of pressure grease systems, it is important that the circulation system be properly maintained and the oil kept free from contamination. Contamination is always worse on mills where a roll coolant is used. The coolant is either water or water to which some material is added to give the desired rolling results. Water contamination can be reduced to a minimum by proper seal and chock maintenance. With the Morgoil bearing it is seldom, if ever, necessary to completely dismantle the bearings when the rolls are removed for grinding. Consequently, the seals are not disturbed. In the Mesta bearing installations, however, the bearings are usually removed at each roll grinding. There are four seal rings in each bearing assembly which must be properly seated and fit each time a bearing is installed.

When installing a Mesta bearing on a roll, the seal rings have to pass over a series of "slinger" grooves machined at the outboard and inboard ends of the roll neck. In passing over these grooves, the seal rings, often times, are damaged. In order to minimize such seal damage, a number of mills now are filling in these grooves on present rolls and are ordering new rolls without them.

Water leaking past the seals, when circulated with the oil through the bearing clearances and pumps, will form a persistent permanent type of emulsion. Such emulsions are heavy and will have the effect of increasing the viscosity of the oil. Also, as the water content of the oil increases, the continuity of the oil film may be affected.

Therefore, steps should always be taken to remove the water contamination. Since the type of emulsion formed cannot be broken by any kind of mechanical filtering, to remove the water, therefore, it is necessary to heat the oil to about 180 F and allow the water to settle out. If the emulsion is not completely broken so that all water contamination will drop out on one heating of the oil, certain materials known as emulsion breakers can be added to the oil in very small percentages which will speed up the water separation. Any material so added should be of such a nature as to be completely removed with the water, so that no deposits will be formed in the system or bearings when the oil treated with it is put back into service.

Under certain operating conditions, bearing surfaces may have a pulled appearance which is often times thought to be caused by a lubrication failure. Usually, when this condition is observed, the bearings have been operating with no apparent trouble. This wiped condition, in practically every case, results from excessive bearing distortion when the mill is started from standstill under excessive loads. When so started, the bearing metal will be pulled or rolled out to form a new bearing surface in a manner very much the same as cold rolling of metal between the rolls of the mill stand.

Bearing misalignment also may result in the same pulled affect. A close examination of the pressure pattern on the bearing surface will show whether the bearing has been in perfect alignment and, if not uniform over the entire length, steps should be taken to correct the cause.

Lubrication, when considered an important part of maintenance, by proper application and interpretation of the results obtained can do much to reduce operating and maintenance costs.

MAINTENANCE OF

Roller Bearings in Steel Plants

By PAUL L. HAAGER
Assistant Chief Engineer
Timken Roller Bearing Co.
Canton, Ohio

. . . . with proper care and maintenance, roller bearings will give a long and satisfactory life . . . .

▲ IN order to secure maximum useful life and performance efficiency from any type of mechanism in use in our manufacturing plants, there must be close coordination between the engineering, mechanical and production departments. It is obviously rather easy for the engineer to set up certain specifications for a machine based upon the characteristics of the loads, speed, operating cycles and operating conditions, but it is up to the mechanical departments to see that proper maintenance to the machine is assured. Similarly, the production department can be of great help in cooperating with the mechanical department to be certain that the equipment is properly used in accordance with those specifications.

Therefore, all bearing applications must receive the best thoughts as far as bearing selections are concerned, based on loads, speed and other operating conditions, as well as provisions for proper handling in assembly and disassembly and effective provisions for proper lubrication and inspection with a minimum of trouble.

Regardless of the class of equipment, it is the first responsibility of the designing engineer for the mill builder to coordinate his thoughts with those of the men who will ultimately operate the mills or equipment and with those men who are charged with the responsibility of providing proper maintenance for the mills.

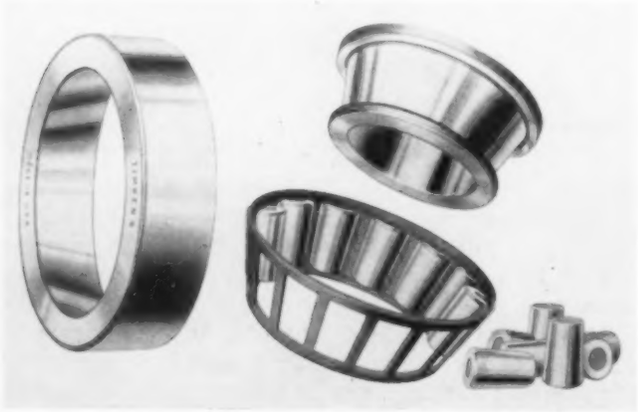
It is the purpose of this paper to attempt to help reestablish some important relationships between the use and maintenance of mill bearings as it is related to original design specifications. We will also attempt to review two major classes or groups of equipment with which the steel mill bearing maintenance man is associated.

Group 1 includes those semi-permanent applications such as rolling mills in which back-up and work roll bearings are changed quite frequently to permit regrinding the roll barrel, to assure good finish and tolerance to the product. It is, therefore, necessary in this type of unit to apply the bearings by a method which will make it possible to change rolls and bearings in a minimum amount of time.

Group 2 includes all such permanent units as gear drives, pinion stands, small reduction units, hot and cold saws, table drives, screwdown drives, reels, processing equipment, coilers and other miscellaneous auxiliaries. These units are invariably built as completely sealed units to give long service free life. Due to the type of lubrication and sealing arrangements these should require a minimum of attention.

Before going into the subject of trouble preventative maintenance I would first like to review quite briefly some basic points having to do with design and types of our tapered roller bearings.

Figure 1 — Component parts of tapered roller bearings.



DESIGN OF TAPERED ROLLER BEARINGS

The tapered roller bearing as used extensively in rolling mills of all types is identical in principle and quite similar in design to those built for the automotive

and railway fields as well as those used in all the many types of industrial equipment.

These are built in a variety of types to satisfy the particular conditions of the type of machine in which they are used. Basically, the single row bearing can be altered in numerous ways in order to obtain such features as tapered bores, flanged cups, keyway cones, etc., and special service and mounting requirements may be provided for by the use of multiple row assemblies of two or four rows of rollers. Each of these serves a very definite purpose from one of providing the required bearing capacity per position to that of satisfying a specific mounting problem.

For clarification purposes, we would like to give you a brief review of the various types of arrangements with which the steel mill man may be confronted. Most of these cover the permanent units of group two unless otherwise specified.

Figure 1 shows the individual parts of the bearing having the cup in the left hand view, the cone in the top view, the rollers in the lower right hand view and a portion of an assembly showing the rollers in the roller separating cage pocket.

Figure 2 shows the many types of arrangements of tapered roller bearings that are available.

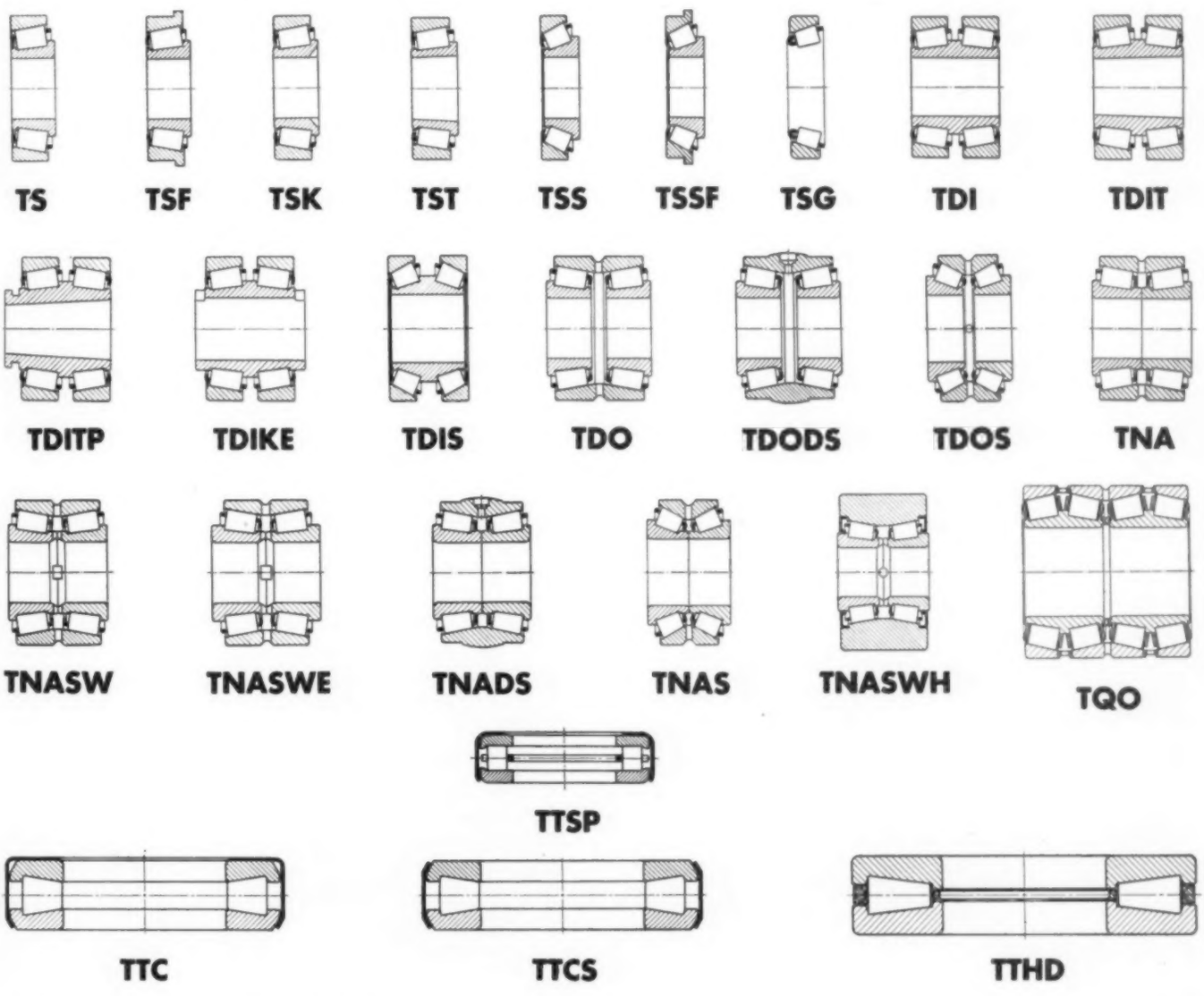
TYPE "TS" SINGLE ROW BEARING

Figure 3 shows a cutaway section showing the general appearance of an assembled single row bearing showing the cup or outer race, the rollers spaced by the separating cage, and the front face view of the cone or inner race. The nomenclature which is commonly used in referring to the individual parts of a tapered roller bearing is also given.

TYPE "TDO" TWO ROW BEARINGS

Figure 4 shows this bearing made up of two cones, one double cup and two cage and roller assemblies. These bearings are many times used on alternate ends of a shaft with one cup fixed at one end and the other cup permitted to float in the housing bore on the other end. In other cases this type bearing may be paired up with a fixed type "TDI" bearing.

Figure 2 — Many types of arrangements of tapered roller bearings are available.



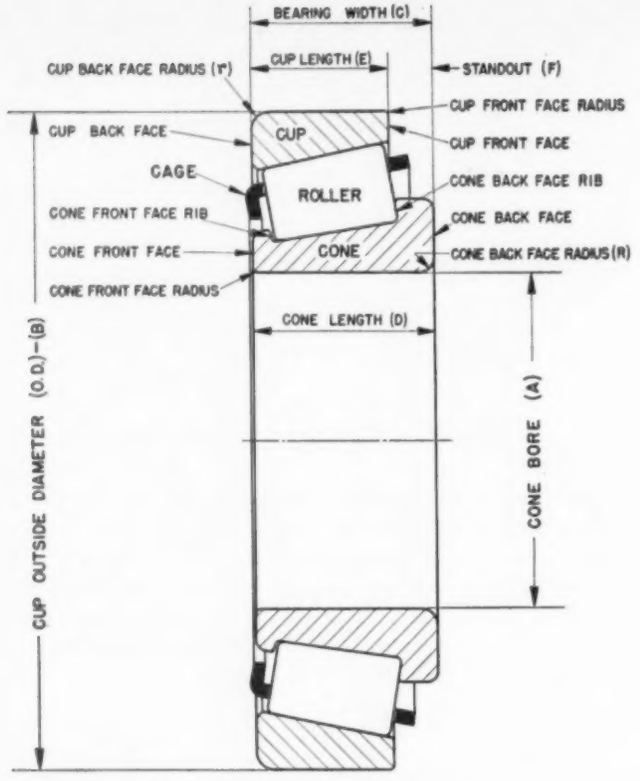


Figure 3 — Cutaway section of single roll bearing.

This bearing may either be set up on the job by means of thin metal shims or nut or furnished, as is the usual case in steel mill equipment, with cone spacers which are properly ground at the factory to give the specific bearing lateral required in the application involved.

TYPE "TNA" TWO ROW BEARINGS

This bearing is quite similar to the Type "TDO" with the exception that instead of using the cone spacer for a non-adjustable arrangement, this particular bearing has the inner portions of the cone extended and ground at the factory to give the proper bearing lateral or end play. The advantage of this type of arrangement over the "TDO" with cone spacer is in the fact that all cones are interchangeable with all cups. This is accomplished by match grinding all cones to the same stand in a master and grinding the cups all to the same stand to a master plug. This type of bearing has found a wide range of use.

TYPE "TNASW" AND "TNASWE" TWO ROW BEARINGS

Type "TNASW" and "TNASWE" bearings have been developed for use on sheave applications. The type "TNASW" has the same overall width as the standard type "TNA" bearing and has, fundamentally, the same overall dimensions on bore and O.D. However, in order to provide lubrication to the bearings through the shaft, slots and oil grooves are ground in the front faces of the cones to permit lubrication carried through drilled holes in the shaft to pass into the bearing.

The type "TNASWE" is quite similar to that of the "TNASW" with the exception that the cone ribs are extended in order to accommodate a flinger type closure.

Figure 5 shows a type "TNAHD" bearing designed for use as leveler rollers. These are complete self-contained units provided with closures and are available in a number of sizes.

TYPE "TDI" TWO ROW BEARINGS

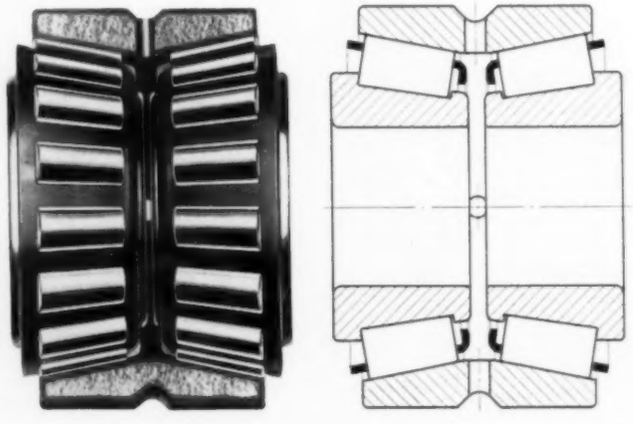
Figure 6 shows this two row type bearing made up of a solid double inner race, two single outer races and two cage and roller assemblies. This type of bearing has the advantage of providing additional capacity over a single row bearing by using two rows of rollers. One of these bearings may be used on one end of a shaft where the other end of the shaft may be carried upon a similar type bearing mounted in a floating cartridge or a type "TDO" or "TNA" free to float through the outer race. These bearings are also used in Class No. 1 equipment on mill roll necks, where the capacity of a 4 row back-up roll bearing is not required.

TYPE "TQO" FOUR ROW BEARINGS

This type bearing shown in Figure 7 shows a cross section of this 4-row bearing. It is made up of two double inner races, two single outer races and one double outer race, together with one cone and two cup spacers. The smaller size bearings are invariably made with a stamped type of cage whereas the larger sizes are made with a pin type cage such as is shown in this particular figure. This bearing is used in 2-Hi, 3-Hi and 4-Hi type installations where maximum loads are prevalent. This balanced proportion bearing was announced to the industry through the Association of Iron & Steel Engineers in 1946. See "Development of Balanced Proportion Roller Bearings for Rolling Mills," by Paul Haager, 1946 Proceedings of the AISE, p 624.

Figure 8 shows the thrust (Type "TTHD") bearing used extensively in piercing mill thrust blocks. This bearing is made up of two quite identical thrust races and a bronze cage and roller assembly.

Figure 4 — This bearing consists of two cones, two cage roller assemblies and one double cup.



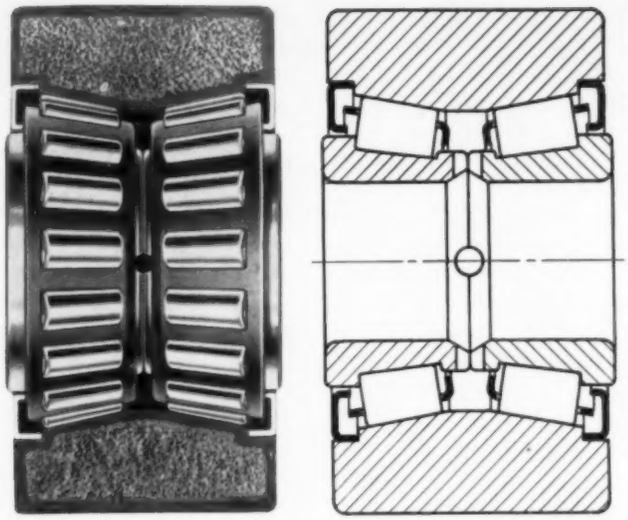


Figure 5 — This bearing is designed for use as leveler rollers.

PART NUMBERING SYSTEM

The individual part number of every cone, cup or spacer is stamped on the component part. The cup number may be stamped on the outside diameter of the cup in the smaller sizes, but in most of the larger bearings, the number is stamped on the face of the cup. The part number of the cone is always stamped on the cone face. Most of the steel mill bearings have serial numbers for identification, in addition to the regular bearing part number.

The part number of our bearing is obtained by combining the part numbers of the individual cones and cups involved in the assembly. Therefore, in the case of a single row type "TS" bearing the part number will be made up of the cone number and cup number. As an example, where the cone number is 99600 and the cup number is 99100, the bearing part number becomes 99600-99100. In the cases of multiple row bearing assemblies, number 99603D-99100 would indicate a "TDI" bearing in which one double cone number 99603D is combined with two single cups number 99100. Furthermore, in the case of type "TQO" bearings which are commonly used in work rolls and backup rolls on both hot and cold mills, it will be recalled that this bearing is made up of two double cones, two single cups and one double cup, together with one cone spacer and two cup spacers. If the two cones are identical and the two single cups are identical, we will have a bearing part number which will consist of three groups of numbers. As an example, bearing number 81601D-81962-81963D such as is found on Line 8 of Page 1-220 of the Timken Engineering Journal Rev. 1950, would be made up of two double cones 81601D, two single cups 81962, one double cup 81963D, all combined with one cone spacer X1-H-81600 and two cup spacers Y-1-S-81963. It should be noted that the spacers are not included in the bearing part number. When a bearing of this type is referred to it will be known as "bearing 81601-D-81962-81963D with cone and cup spacers."

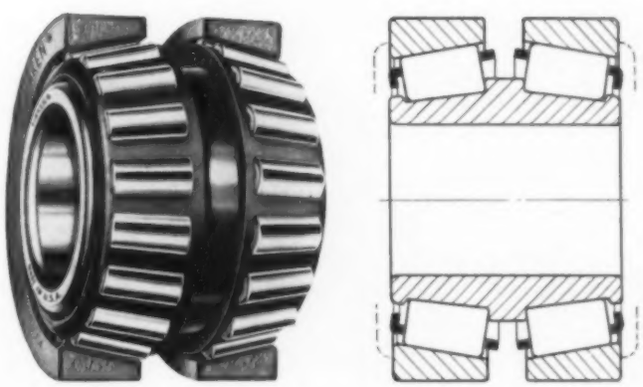
INSPECTION NUMBERING SYSTEM

Serial numbers—In addition to the bearing part number, the bearing is also given a serial number which identifies it with the year in which it is manufactured.

Serial numbers of our bearings consist of two parts, the first part gives the year in which the bearing was made and the second part is a number indicating the bearing in the sequence that it was manufactured during that year. Example: Bearing 50-1 was made in 1950 and was the first one made in that particular year with that particular part number. All the cups, cones and spacers in one particular bearing are marked with the same serial number. All the parts with the same serial number should always be kept together and under no circumstances should various parts of bearings having different serial numbers be interchanged, unless the bearings are remeasured and the spacers reground. The spacers are accurately ground to give the lateral that is necessary and, therefore, one spacer of one serial number cannot be used as a spacer in another bearing having a different serial number, without regrinding the spacer to meet the requirements of lateral for the second bearing.

Figure 9 shows the markings that are currently used on our "TQO" bearings to help identify the various parts in order to keep the parts in proper sequence during assembly. It will be noted that the serial number, previously mentioned, the bearing part number or race part number, the bench lateral which is built into the bearing spacers, and the name of the company producing the bearing, are plainly marked on each of the faces. In addition, in the case of back-up roll bearings, four load zones are indicated as 1, 2, 3, and 4 in order that it may be possible to promote long life. Where high separating forces are applied to roll neck bearings, the inside cup surfaces in the load zone receives the greater amount of fatigue usually found at the center of the bearing load zone. Since the cups or outer races, do not rotate and do not change their position after they are once placed in the chuck, these particular zones will be subjected to the rolling load until the cups are turned. By having a number of zones, as above mentioned, the useful life of the bearing can be extended by turning the outer races or cups into the load line at frequent intervals. The frequency of this change

Figure 6 — This two row type bearing consists of a solid double inner race, two single outer races and two cage and roller assemblies.



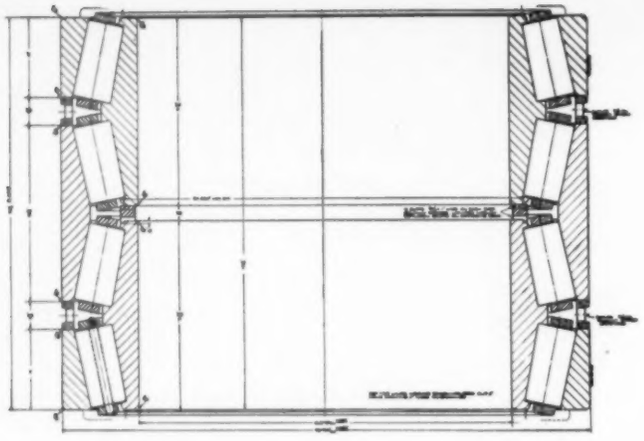


Figure 7 — Cross section of 4-row bearing.

will be based upon the number of times that the bearing is taken from the chuck for inspection.

It will be noted that the cup and cone spacers are marked with the part number, the serial number and also the width. This width dimension is greater than the space dimension marked on the adjacent race face by the amount of bench lateral which is desired.

It will be noted that the faces of the bearing parts are identified by the letters "A" to "E" inclusive. Starting with one end of the assembly, the A-B cup is the first race. Next is the B cup spacer, followed by the AC cone and roller assembly. We next have the double cup BD, followed by a cone spacer which is located between the AC cone and roller assembly and the following CE cone and roller assembly. This is then completed with the D cup spacer and the D-E cup. The corresponding faces are, therefore, all marked with a corresponding letter, thereby assuring that the bearings are properly assembled.

Mill roll thrust loads are carried through the cone faces. The cones tend to creep on the shaft with the result that the bearing serial number letters and space readings which are normally etched on these cone faces may finally be completely worn from these surfaces. In order to maintain these records, the numbers and letters are also etched or stamped on the bearing cages of the adjacent cone faces.

Figure 8 — Thrust type tapered roller bearing.

CLASS NO. 1 — ROLL NECKS

Bearing loading vs life—With the advent of balanced proportion bearings, larger necks have been obtained simultaneously with an increase in bearing capacity. In the case of 4-Hi cold tandem mills it is many times necessary to take a very high reduction in the final passes in order to obtain certain characteristics of strip finish. Many times the loading on the finishing pass exceeds the loads on any of the other passes by a considerable amount. If the bearing is selected to meet the conditions of the highest loaded stand, it would mean that the bearings in the other stands would have greater capacity than would normally be necessary. The interchange of bearings between stands is therefore a common practice and fits quite naturally into the overall mill maintenance program since mill rolls are also changed from stand to stand in order to prolong their useful life. Finishing passes require the most accurate and highly polished roll surface finishes whereas the primary passes may permit surface finishes of a lower grade. This natural load and mill roll balancing effect between various mill stands is not only true on cold rolls but on hot continuous strip mills as well.

Strain gages—The close control of mill loading by the use of modern calibrated strain gages aids further in controlling mill separating forces which not only have their effect on roll neck bearings, but on all related parts of the mill and rolls as well. Their use assists the rolling mill operator in maintaining a uniform rolling schedule which in the case of cold finishing mills helps in controlling the shape of the mill roll as it pertains to mill roll crowning and mill roll deflection. They also help in maintaining proper gage across the strip width.

Type "TQO", four row mill roll neck mounting—A review of the important provisions in the mounting of this type of bearing should be quite in order since a number of features have been built into the mounting design for this bearing to facilitate removal of the bearing from the roll neck in a minimum of time and to reassemble the bearing and chuck on the roll neck rapidly.

Due to the necessity for quick roll and bearing changes the bearings are invariably mounted with a loose fit of both inner and outer races. The inner races are usually mounted with a loose fit of approximately 0.0005 in. per in. of neck diameter. This looseness will permit a slight creepage of the cone on the neck and thereby draw lubricant into the clearance between the bearing bore and the neck outside diameter. Where excessively high speeds are involved, rifle drilling the necks for separate neck lubrication is recommended. On slower speed mills, provisions for lubrication of the neck outside diameter with a light coating of regular bearing grease, has been beneficial and economical.

Referring to Figure 10, it will be noted that the inner

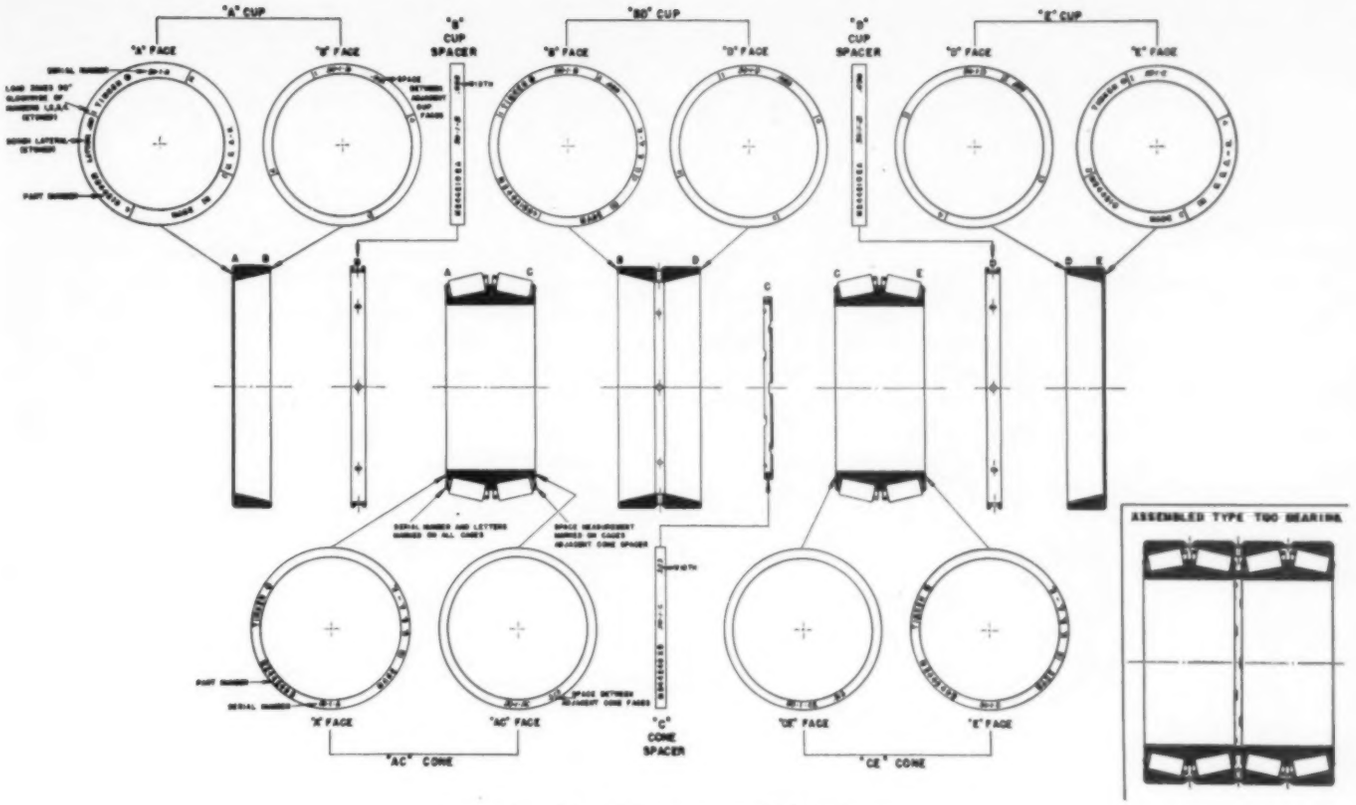


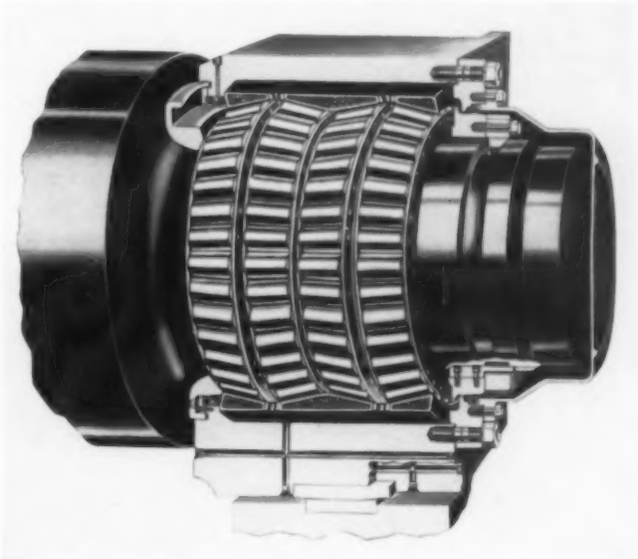
Figure 9 — Markings of type TQO bearings.

face of the bearing cone is separated from the main roll barrel by means of a fillet ring. The ring, in this case, is clamped to the roll barrel to eliminate any possibility of its turning on the neck. In some cases the ring is made a loose fit on the neck and then locked against rotation to the neck. Where this design is used, it is usually necessary to use a special packing between the ring and the roll barrel to avoid the possibility of water passing through the clearances provided by the loose fit of the ring. The bearing is held against the fillet ring by means of the outer clamp ring which is in turn keyed against rotation and held in its position by means of a threaded nut fitted about a split retainer ring. This retainer ring is fitted into a groove in the roll neck at this point and pinned against rotation. This arrangement provides a very positive means of clamping the bearings. The nut shown is made with a number of slots on its outer diameter to aid in pulling it tight against the assembly. In order to get a vernier variable of locking positions, the clamp ring is provided with tapped holes, the number of which is usually one less than the number of corresponding drilled holes in the nut which accommodates the locking screw.

The bearing is furnished as a complete unit assembly together with proper cone and cup spacers in order to provide proper controlled running clearance for the bearing and providing possible future compensation for service wear or wear from dirt getting into the assemblies.

The faces of the fillet ring and clamp ring as well as the faces of the cone spacer on this application are hardened and provided with a number of lubricant slots. These slots allow the lubricant to pass from the bearing chamber to the clearances between the neck surface and the bearing bore. It is obvious that if a bearing is to function satisfactorily it must be properly protected from foreign matter. The closure arrangement shown has been found quite efficient in many installations. The use of a combination of a water or dirt shield with a pair of commercial seals is recommended in those cases where provisions for lubrication of the clearances between the two commercial seals is made.

Figure 10 — Sketch shows mounting of 4-row bearing on roll neck.



A unit chuck and bearing assembly is provided in order that the chuck with bearings may be readily transferred from one roll to another without loss or contamination of the lubricant within the bearings. The inner lip extensions of these chucks are made with a close running clearance adjacent the inner race of the bearing. The radial flange on the clamp ring holds it with the chuck when the bearing and chuck unit is removed from a roll. Chucks and bearings may be removed from a roll by merely removing the cone clamp nut and sliding the chuck with bearing from the neck.

Lubricant is applied to the bearing through leads to each cup spacer. Extreme pressure non-fluid lubricants are invariably recommended for bearing lubrication. No elaborate lubrication pipes or fittings are necessary with this system, thereby permitting roll changes in a minimum of time and without loss of lubricant. Bottom roll chucks are provided with rocker shoes or flats with bevels to permit the chuck to rock when sudden momentary overloads occur.

It is to be noted that the roller bearing carries all combinations of both radial and thrust loads and that no external supports for special thrust units are necessary with this type of bearing.

"TQO" work roll mounting—Figure 11 shows the arrangement of the "TQO" bearing on work rolls of 4-high mills. The general features of the design are quite similar to that for back-up rolls with the exception of the capacity and size of bearing necessary.

Figure 12 shows a complete assembly procedure for the Type "TQO" four-row mill type bearing as used in back-up and work rolls of steel and non-ferrous rolling mill roll necks. It is very important that the proper letter sequence is followed in assembling the bearings.

Bearing installation—When the bearing is being prepared for installation in the chuck in which it is to be used, handling tools may be properly inserted in the cage of the bearing where properly tapped holes are provided. Figure 13 shows how these handling tools are arranged and how the bearing may be supported and properly assembled into the back-up roll chuck.

Figure 14 shows an assembly procedure in the case of two row bearings. Here the importance is centered around a matter of keeping all parts in "letter" sequence.

Loose cone neck applications — It was previously stated that bearing cones of "TQO" and "TDI" bearings in mill roll necks are invariably mounted with a loose fit equal approximately to 0.0005 in. loose per in. of neck diameter. This permits rapid disassembly of the bearing and chuck from the roll neck. In the case of hot mill work roll bearings, these are changed quite often. In other high precision cold finishing mills, the rolls may be changed as frequently as six times in an eight hour period. When bearings are removed from one roll neck and placed on the other, lubricant should be applied to the roll neck in order to assist in providing lubrication between the cone bore and neck O.D. There have been instances where a graphite paste has been used with some degree of success. In other cases where rather high speeds are involved, provisions are made to introduce lubricant between the roll neck and the bearing cone to prevent scuffing of the roll neck. In still other cases, the necks are drilled at right angles to the axis of the neck and are supplied with a fitting in order that the cone bores can be lubricated by means of a pressure grease gun when the mill is shut down. In other cases, a swivel fitting can be provided through which the lubricant can be delivered to the bearing cones at periodical intervals during actual mill operation.

Piercing mill main roll—Figure 15 shows the mounting of a 4-row Timken bearing on the main roll of a seamless tube mill. Heavy duty 4-row bearings are used in this application with the provision that the cones be applied with a loose fit on the shaft in order to make it possible to remove the bearings from the necks rapidly. In some of these installations, the speeds are relatively high and for that reason lubrication is provided between the cone bore and the neck O.D. The

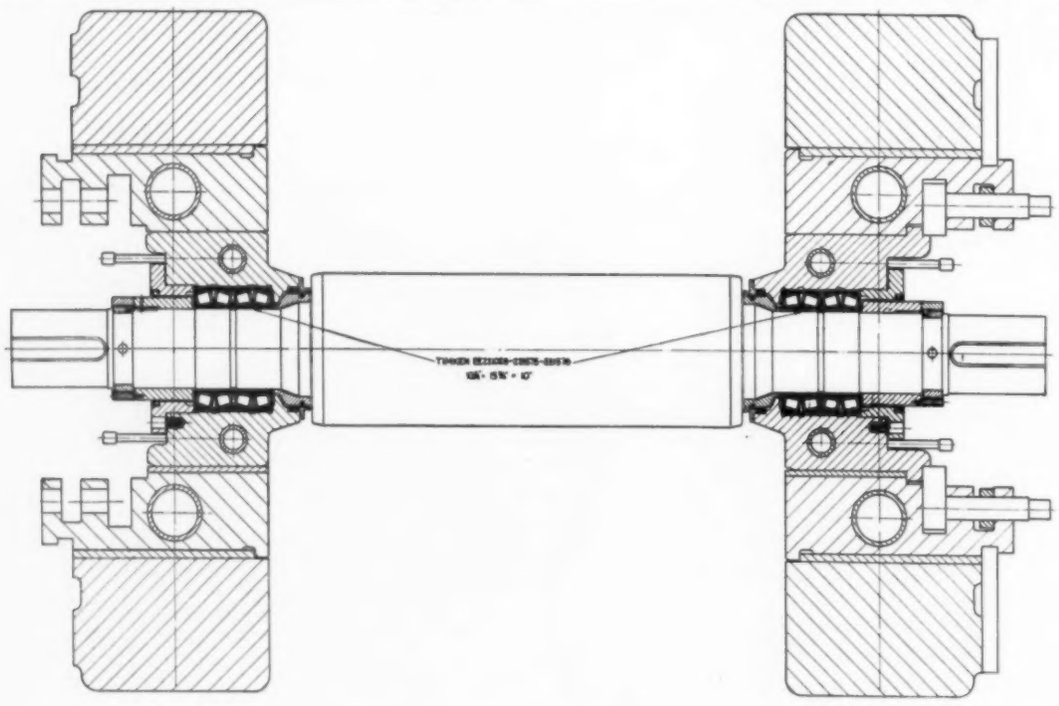


Figure 11 — Arrangement of bearings and work rolls on 4-high mills.

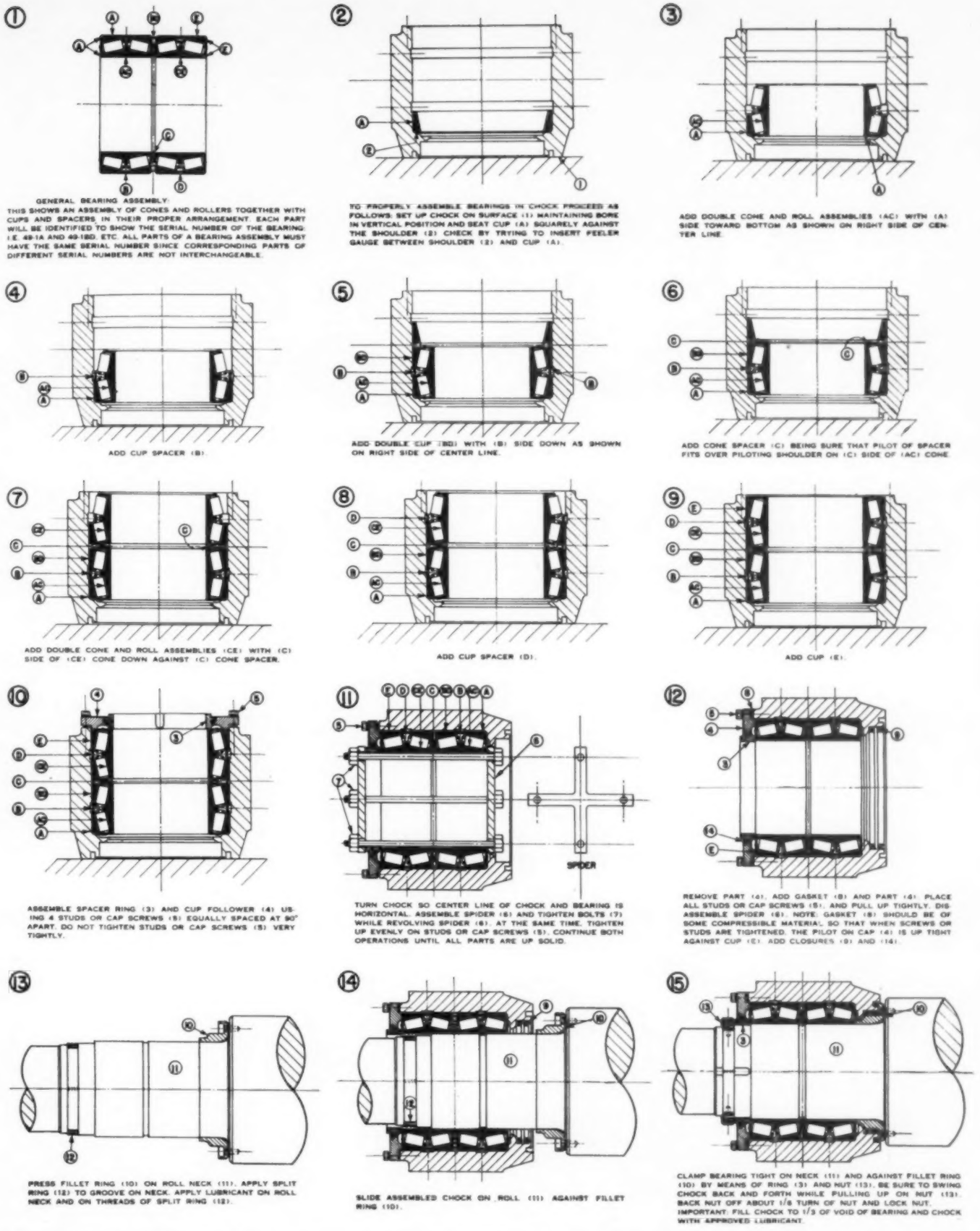

①
GENERAL BEARING ASSEMBLY:
THIS SHOWS AN ASSEMBLY OF CONES AND ROLLERS TOGETHER WITH CUPS AND SPACERS IN THEIR PROPER ARRANGEMENT. EACH PART WILL BE IDENTIFIED TO SHOW THE SERIAL NUMBER OF THE BEARING: I.E. 49-1A AND 49-1BD, ETC. ALL PARTS OF A BEARING ASSEMBLY MUST HAVE THE SAME SERIAL NUMBER SINCE CORRESPONDING PARTS OF DIFFERENT SERIAL NUMBERS ARE NOT INTERCHANGEABLE.
②
TO PROPERLY ASSEMBLE BEARINGS IN CHOCK PROCEED AS FOLLOWS: SET UP CHOCK ON SURFACE (1) MAINTAINING BORE IN VERTICAL POSITION AND SEAT CUP (A) SQUARELY AGAINST THE SHOULDER (2) CHECK BY TRYING TO INSERT FEELER GAUGE BETWEEN SHOULDER (2) AND CUP (A).
③
ADD DOUBLE CONE AND ROLL ASSEMBLIES (AC) WITH (A) SIDE TOWARD BOTTOM AS SHOWN ON RIGHT SIDE OF CENTER LINE.
④
ADD CUP SPACER (B).
⑤
ADD DOUBLE CUP (BD) WITH (B) SIDE DOWN AS SHOWN ON RIGHT SIDE OF CENTER LINE.
⑥
ADD CONE SPACER (C) BEING SURE THAT PILOT OF SPACER FITS OVER PILOTING SHOULDER ON (C) SIDE OF (AC) CONE
⑦
ADD DOUBLE CONE AND ROLL ASSEMBLIES (CE) WITH (C) SIDE OF (CE) CONE DOWN AGAINST (C) CONE SPACER.
⑧
ADD CUP SPACER (D).
⑨
ADD CUP (E).
⑩
ASSEMBLE SPACER RING (3) AND CUP FOLLOWER (4) USING 4 STUDS OR CAP SCREWS (5) EQUALLY SPACED AT 90° APART. DO NOT TIGHTEN STUDS OR CAP SCREWS (5) VERY TIGHTLY.
⑪
SPIDER
TURN CHOCK SO CENTER LINE OF CHOCK AND BEARING IS HORIZONTAL. ASSEMBLE SPIDER (6) AND TIGHTEN BOLTS (7) WHILE REVOLVING SPIDER (6). AT THE SAME TIME, TIGHTEN UP EVENLY ON STUDS OR CAP SCREWS (5). CONTINUE BOTH OPERATIONS UNTIL ALL PARTS ARE UP SOLID.
⑫
REMOVE PART (4), ADD GASKET (8) AND PART (4). PLACE ALL STUDS OR CAP SCREWS (5), AND PULL UP TIGHTLY. DISASSEMBLE SPIDER (6). NOTE: GASKET (8) SHOULD BE OF SOME COMPRESSIBLE MATERIAL SO THAT WHEN SCREWS OR STUDS ARE TIGHTENED, THE PILOT ON CAP (4) IS UP TIGHT AGAINST CUP (E). ADD CLOSURES (9) AND (14).
⑬
PRESS FILLET RING (10) ON ROLL NECK (11). APPLY SPLIT RING (12) TO GROOVE ON NECK. APPLY LUBRICANT ON ROLL NECK AND ON THREADS OF SPLIT RING (12).
⑭
SLIDE ASSEMBLED CHOCK ON ROLL (11) AGAINST FILLET RING (10).
⑮
CLAMP BEARING TIGHT ON NECK (11) AND AGAINST FILLET RING (10) BY MEANS OF RING (3) AND NUT (13). BE SURE TO SWING CHOCK BACK AND FORTH WHILE PULLING UP ON NUT (13). BACK NUT OFF ABOUT 1/8 TURN OF NUT AND LOCK NUT. IMPORTANT: FILL CHOCK TO 1/3 OF VOID OF BEARING AND CHOCK WITH APPROVED LUBRICANT.

Figure 12 — Assembly procedure for mounting four-row bearing on roll necks with pressed steel or pin type cages.

above figure shows the provision of a lubricant fitting leading radially down to the axis of the shaft and then through a rifle drilled hole along the axis from which leads are provided in a radial direction to lead the lubricant directly under the cones.

Table I shows the fitting practice which is to be used

TABLE I

CONE FITTING PRACTICE

Bores		Neck diameter is Normal bearing bore		
Over, in.	To, in.	Max., in.	Min., in.	Fit, in.
2	3	—0.002	—0.003	0.002 to 0.004 Loose
3	4	—0.003	—0.004	0.003 to 0.005 Loose
4	5	—0.004	—0.005	0.004 to 0.006 Loose
5	6	—0.005	—0.006	0.005 to 0.007 Loose
6	8	—0.006	—0.007	0.006 to 0.008 Loose
8	12	—0.007	—0.008	0.007 to 0.009 Loose
12	24	—0.008	—0.010	0.008 to 0.012 Loose
24	36	—0.010	—0.013	0.010 to 0.016 Loose

in applying cones on steel mill roll necks wherein a loose fit application is involved. If the roll necks are not held to the usual tolerances as specified on this table, excessive neck scuffing may result. This is due to the fact that the circumference of the cone bore is greater than the circumference of the neck O.D. and the neck rolls in the cone bore somewhat similar to a planet pinion in an internal ring gear. However, under load we get a width of contact with sliding at the outer edges. We find that it is impossible to go to a cone fit much less than 0.002 in. loose and still assure ample lubrication of the roll neck. When the clearances are reduced below the 0.002 in. the surfaces between the cone bore and the neck O.D. are liable to become dry and the maintenance of an oil film with these smaller clearances is doubtful. It will be noted that the clearances are progressively greater as we consider an increase in bearing bore. Bearings from 12 to 24 in. are set with a standard fit of 0.0080 in. loose to 0.0120 in. loose. From 24 to 36 in. they are fitted 0.010 to 0.016 in. loose. Due to the impossibility of assuring these limits at all times, and since roll necks tend to decrease in size through service, there are obviously certain limitations that should be placed upon the smallest neck that could be considered as still satisfactory. The neck should be rebuilt at frequent intervals wherever possible if it is found that the useful life of the roll barrel outside diameter is sufficient to justify the rebuilding program.

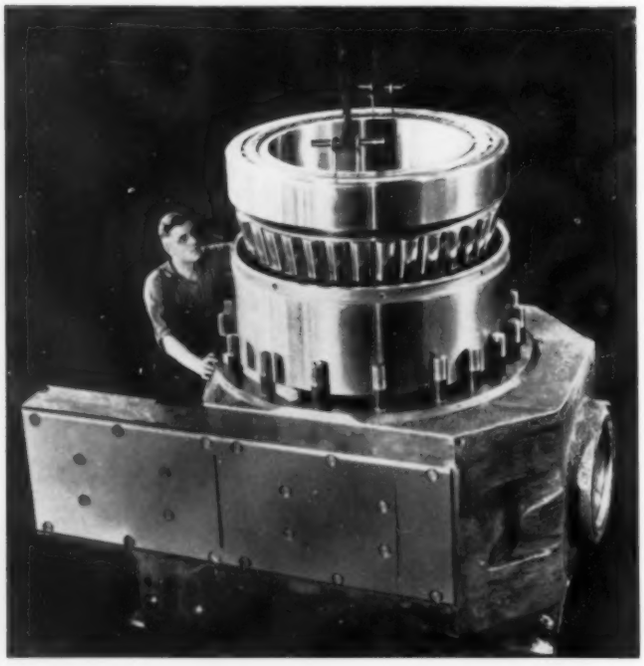
Table II gives a general table which has been found practical as a general guide in determining at which point the neck diameter should be rebuilt. It is to be noted that this varies from 0.012 in. less than the normal bore of the bearing for the bearings up to 3 in: bore to as much as 0.048 in. under the normal bore of the bearing for those bearings running from 24 to 36 in. in bore. It is conceded however, that there are undoubtedly numerous cases where the wear on the roll necks has actually exceeded this amount and that relatively good bearing life has been obtained. This, however, is not good practice in keeping with best bearing life, since off size necks tend to cause poor distribution of loading in the rollers in the bearing.

TABLE II

PERMISSIBLE SERVICE WEAR ON MILL ROLL NECKS

Cone bores, in.	Permissible minimum neck diameter (Normal bearing cone bore, in.)
to 3	—0.012
+ 3 to 4	—0.015
+ 4 to 5	—0.018
+ 5 to 6	—0.021
+ 6 to 8	—0.024
+ 8 to 12	—0.027
+12 to 24	—0.036
+24 to 36	—0.048

Figure 13 — Proper method of supporting bearing and assembling it into backup roll chuck.



Roll neck surface preparation—Neck wear and neck scuffing can be greatly minimized by taking certain precautions in the selection of mill rolls. The necks should carry as high a surface hardness as is possible to obtain. A considerable amount of experimental work is being conducted in trying to establish methods of providing dissimilar metals between the adjacent parts of the cone bore and the neck O.D. in order to reduce the coefficient of friction between the creeping members. In a number of installations, chrome-plating the necks has helped considerably, and in still others nickel-plating has shown a decided improvement. There is also the factor of not only obtaining two dissimilar metals in order to neutralize the tendency of seizing of parts in contact under high unit loads from frictional drag, but also one of obtaining a high surface hardness on the roll neck. It is to be remembered that not only is the cone bore ground to a high finish but also that it is provided with a surface hardness of approximately 60 Rockwell "C."

Tight cone fits—Tight fits are recommended in the case of extremely high speed mills to avoid neck scuffing. In most of these high speed applications the cones are invariably made with a tapered bore. In the case of the tapered roller bearing, the most common type of bearing for obtaining a tapered bore has in the past been a 2-row type. This is known as our "TDIT" as is shown on Figure 16. This mounting is typical of that used in rod and bar mills. This design also lends itself

THE PART NUMBER OF EACH COMPONENT PART OF THIS TIMKEN TWO ROW BEARING HAS BEEN STAMPED ON THE PART ITSELF. A SERIAL NUMBER HAS BEEN ASSIGNED TO THIS TIMKEN TWO ROW BEARING, WHICH SERIAL NUMBER HAS BEEN ETCHED ON ALL COMPONENT PARTS.

IN ADDITION TO THE ETCHING OF THE SERIAL NUMBER ON EACH PART A LETTER OR LETTERS "A, B, AC ETC" HAVE BEEN ETCHED ON EACH PART TO ASSIST YOU IN THE ASSEMBLY OF THIS TIMKEN BEARING.

THE DRAWINGS BELOW SHOW THE LOCATION OF THESE LETTERS ON EACH PART.

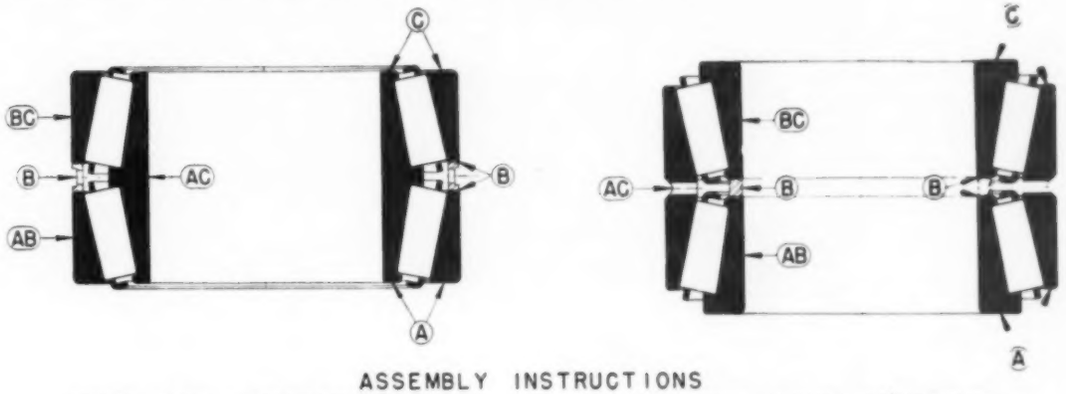


Figure 14 — Assembly of two-row bearings.

ASSEMBLY INSTRUCTIONS

TYPE "TDI" BEARINGS

1. PLACE THE "AC" DOUBLE CONE INSIDE THE "AB" SINGLE CUP WITH THE "A" FACE OF THE DOUBLE CONE AT THE BOTTOM.
2. PLACE THE "B" CUP SPACER ON THE "B" FACE OF THE "AB" SINGLE CUP.
3. PLACE THE "CB" SINGLE CUP ON TOP OF THE "B" CUP SPACER WITH THE "B" SIDE AGAINST THE "B" CUP SPACER.

TYPE "TDO" BEARINGS

1. PLACE THE "AC" DOUBLE CUP ON THE "AB" SINGLE CONE WITH THE "A" FACE OF THE DOUBLE CUP AT THE BOTTOM.
2. PLACE THE "B" CONE SPACER INSIDE THE DOUBLE CUP, ON THE "B" FACE OF THE "AB" SINGLE CONE.
3. PLACE THE "BC" SINGLE CONE ON TOP OF THE "B" CONE SPACER WITH THE "B" SIDE AGAINST THE "B" CONE SPACER.

quite readily to precision mills either low or high speeds. This design invariably uses a taper of the cone bore of about 1 in. per foot with some other installations using a more rapid taper in order to get a non-locking taper. The bearings may in some cases be slightly warmed before assembly on the roll necks to assure proper seating of the tapers and are clamped tight by means of a suitable nut. This design shows a thick split shim shown between the inner closure follower and chuck which is removed to allow the chuck inner face to bear against the bearing cone. The bearing may then be removed from the neck by wedging between the chuck and roller barrel body or by applying pressure against the face of the closure adjacent to the roll barrel.

Many investigations have been made into the system of hydraulics as it pertains to the removal of bearings and machined parts having press fits. It has been found that by providing proper oil or fluid leads to a pressure groove under the cone, a system of hydraulics can be used in removing such parts. This is obviously a case of expanding the race sufficiently to relieve the interference fit and permitting the part to be removed from the shaft. By using a tapered bore bearing the fluid will not only expand the bearing in the radial direction but also force it in an axial direction, depending upon the taper and the length of the race. Excel-

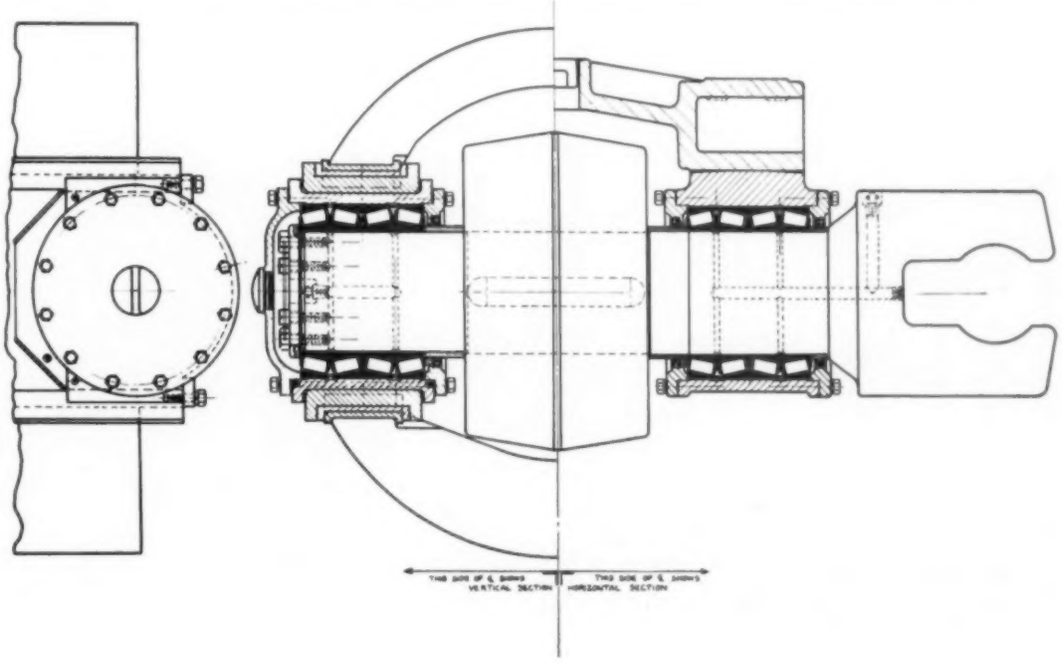


Figure 15 — Method of mounting four-row bearing on main roll of seamless tube mill.

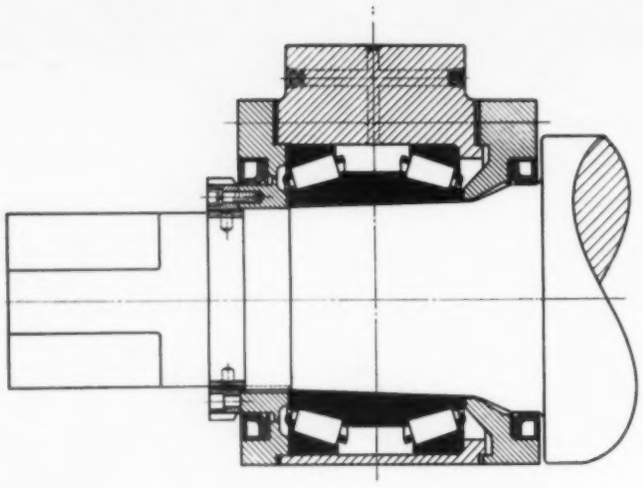


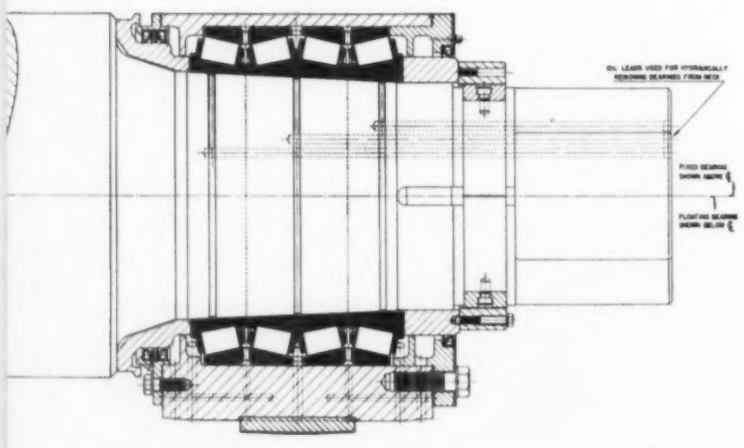
Figure 16 — Typical mounting for high speed mill.

lent results have been obtained with this system in many applications.

One of the advantages of the tapered bore 2-row bearing arrangement lies with the fact that the bearing can be set up by means of thin metal shims to provide the proper operating end play within the bearings and to meet the conditions of speed involved. In some precision mills it has been found quite practical and advantageous to regrind the mill roll barrel on the bearing by resetting the bearings with a slight preload by removing some of the shims between the cup follower and the chuck before placing the bearing and chuck assembly on the grinder bed. This method assures us of a very accurately ground roll by the fact that the small runout of the cone section has been entirely eliminated. In precision bearings the rollers in the bearing are invariably selected to within 0.0001 in. tolerance, which makes for a very accurate bearing assembly and provides a highly finished accurately ground roll barrel.

In associated industries such as plastic calenders, it has been found possible to grind calender rolls of 80 to 90 in. in length to roll barrel run-outs of less than 0.0002 in. This leads into accurate product tolerances by which a material thickness of 0.004 to 0.005 in. can be held to within 5 per cent.

Figure 17 — This four-row tapered roller bearing features an interference fit between the inner races and roll neck.



Many two row straight bore type "TDI" bearings have also been applied with a press fit in small precision mills rolling a variety of products. In the larger mills this is not usually practical due to the greater difficulty encountered in removing a large straight bore bearing applied with an interference fit. Here again, these problems of cone removal can be greatly simplified and the time element reduced by the use of a hydraulic system for expanding the cones.

Research is presently being conducted on special bearings and mounting designs with the object of providing tapered roller bearings which will be practical with interference cone fits in high speed mill roll necks. These bearings will feature four-row assemblies with tapered bores thereby providing sufficient capacity at the higher cold mill speeds, with which the industry is confronted. Mills using this type of bearing are under construction and others are progressing rapidly in the design stages.

Four row roll neck bearings for high speed mills—Figure 17 shows the use of a completely new type of four-row tapered roller bearing which features an interference fit between the inner races and the roll neck and still permits rapid bearing removal from the roll neck. This is accomplished by using a tapered four-row type bearing in which the assembly is made up of two sets of indirectly mounted rows of rollers. This arrangement of the rollers within the assembly permits a larger neck diameter than is possible with any other arrangement and provides better distribution of load over the four rows of rollers.

We have developed an entirely new method of match grinding the tapered bearing bores and have proposed a method of match grinding the fillet rings and roll necks to permit using all bearings interchangeably on all roll necks.

The design above the roll neck horizontal centerline shows the bearings mounted in the fixed chucks on the operating end with the outer races clamped in the chuck, whereas, the design below the centerline indicates a clearance between the cup faces and the chuck faces on the inside and between the cup follower face and the cup on the outside in order to permit the bearing to float in the chuck. This permits free expansion and contraction of the roll caused by variations in bearing and mill roll temperatures, and also permits free axial movement to allow for inaccuracies of machine work.

The bearings can be easily removed from the roll neck by the use of a hydraulic pressure system through the oil leads to the bearing's inner races. This application, as is the case with all four-row roller bearing mountings, eliminates the necessity of special thrust units which are necessary in straight radial bearings, thereby reducing the chuck width considerably.

Since its introduction to the trade, inquiries concerning its possible uses have developed rapidly. This bearing arrangement permits a wide range of use on high speed hot and cold mills and also high speed bar and rod mills.

Cup fitting practice for mill chucks—Table III shows that the cups in mill type roll neck bearings are applied with a fit of 0.001 to 0.003 in. loose up to 12 in. cup O.D. to as high as 0.005 in. loose to 0.015 in. loose for

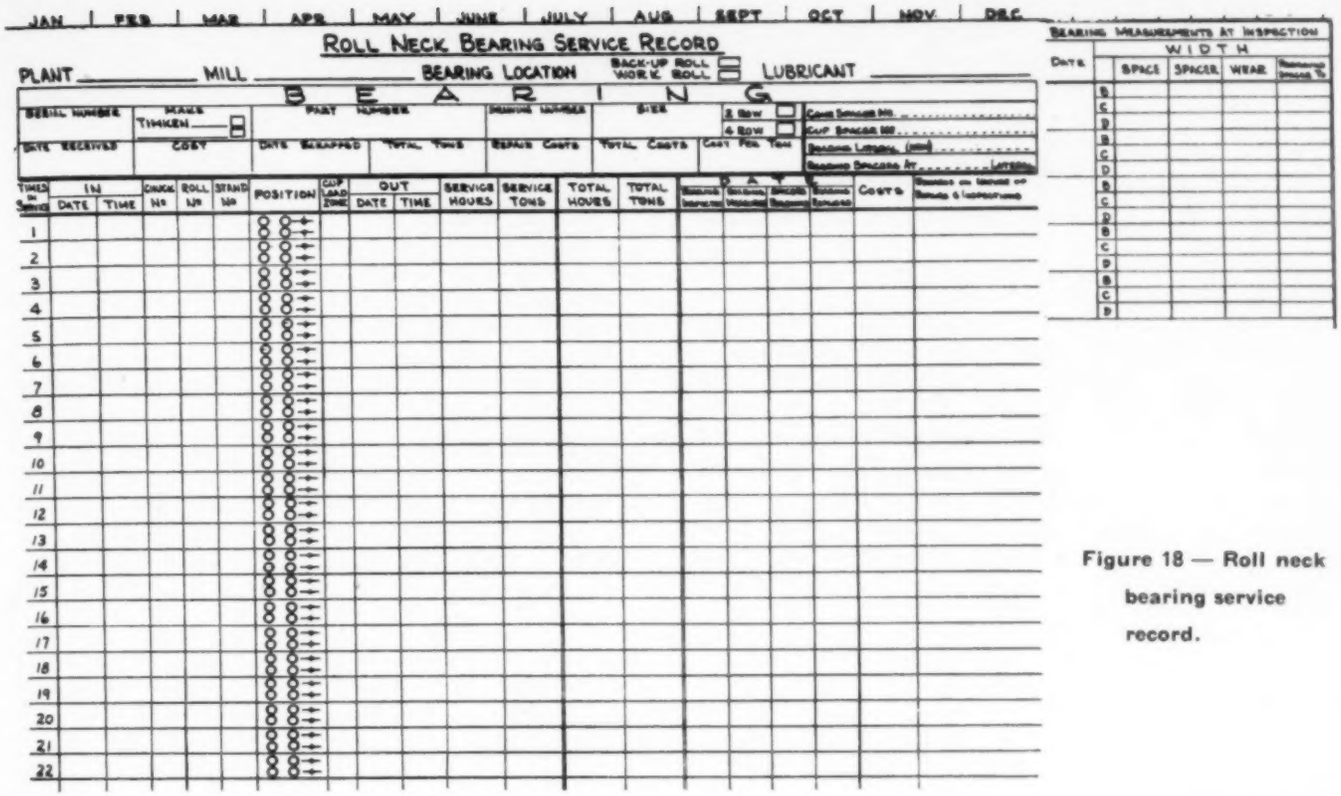


Figure 18 — Roll neck bearing service record.

TABLE III

CUP FITTING PRACTICE

Outside diameter, in.		Chock bore is normal cup outside diameter, in.		
Over	To	Min	Max	Fit, in.
0	12	+0.002	+0.003	0.001 to 0.003 Loose
12	24	+0.004	+0.006	0.002 to 0.006 Loose
24	36	+0.006	+0.009	0.003 to 0.009 Loose
36	48	+0.008	+0.012	0.004 to 0.012 Loose
48	60	+0.010	+0.015	0.005 to 0.015 Loose

cups from 48 to 60 in. outside diameter. It is obviously advantageous to maintain the fits as shown in the above table at all times. However, this is practically impossible due to the fact that heavy shock loads are the usual case in steel mill roll neck applications with the result that a pounding action occurs in the chuck bore. This causes the chuck bores to go out of round and out of shape. Although the ideal is preferable, it is realized that this is also impossible. Experience has indicated that the chuck bores should be rebuilt after they become badly out-of-round but it is not always found possible to set up exact procedures for this repair program. Table IV shows a tabulation of permissible changes in chuck bores from service based on general experience throughout the industry. It is noted that cups up to 12 in. outside diameter might have chuck bore out-of-round limits up to as high as 0.006 in. variation where the maximum chuck bores are not greater than 0.009 in. over the normal cup O.D. It also shows that on cups from 48 to 60 in. outside diameter the out-of-round limits should be kept under 0.030 in. and that the maximum chuck bores should not be greater than

TABLE IV

PERMISSIBLE CHANGES IN CHOCK BORES FROM SERVICE

Cup outside diameter, in.	Maximum chock bore "out-of-round" limits, in.	Maximum chock bore (normal + in.)
to 12	0.006	+0.009
+12 to 24	0.012	+0.018
+24 to 36	0.018	+0.027
+36 to 48	0.024	+0.036
+48 to 60	0.030	+0.048

0.048 in. over the normal cup O.D. This is not a hard and fast rule, but it does give the mill maintenance men an opportunity to classify the conditions of his chucks in keeping with the general experience throughout industry.

INSPECTION AND SERVICE CONTROLS

Bearing life records—As far as loading is concerned, it might be possible to make roll neck bearings selections for 4-hi mills which would have unlimited life, but it would not be economical to do so. Such bearings would necessitate large back-up rolls involving a larger increase in capital investment. Most bearings are selected to give an average of about 15,000 hours life when the proper operational factors are used. The cycle of operation in the hot mill is not to be compared with the cycle of operation in a cold mill, and therefore corrective factors are employed. The cold mills are many times preloaded to take the stretch out of the mill housings which results in greater bearing loadings.

In order to balance out the bearing loading as much as possible in connection with multiple stand installa-

tions, such as continuous hot and cold tandem mills, it is rather important that provisions be made to shift the roll neck bearings from one stand to another at frequent intervals so that all bearings will operate approximately the same length of time in each stand. This will lead to a balancing effect on bearing loading and thereby distribute the work more evenly on all the bearings in the mill.

Each of the bearings has a serial number for identification purposes. Similarly, the chucks and rolls in which the bearings are mounted should also be given a proper number for identification purposes. It is then comparatively easy to keep an accurate record of the life of each bearing in each chuck as well as a record of the time during which each bearing or chuck was used in the various locations in the mill train. Figure 18 shows a roll neck bearing service record which has been arranged to serve as a complete record of either bearings, rolls or chucks. It will be noted that this shows the plant, the mill, the bearing location, whether in back-up or work roll positions, and the lubricant used. It also includes the size, serial number and make of bearing, the cone spacer and cup spacer numbers, the lateral built into the bearing when it is new and the date received as well as the cost. The form also includes a summary of the number of times that the bearing was in service and includes the date and time as well as the chuck roll and stand number in which it was used. It also shows whether it was used on the top or bottom position and whether on the operating or drive side of the mill.

This also includes the respective dates and time from which service hours, service tonnage and total hours or tons can be obtained. By providing the dates of bearing inspections or repairs, a complete history of the bearing can be compiled with a minimum of effort. Across the top of the form is a cue record of the months of the year so that an inspection program can be established for any given bearing by properly flagging the month of the year when the bearing should have attention. This or an arrangement of a similar type is highly recommended. We believe that this particular form includes a number of records which most forms used in the past have not incorporated. These forms will be available through our company.

Bearing inspection—When bearings are removed from service, they are invariably quite thoroughly covered with old lubricant which would interfere with a good visual inspection of the bearing parts. It is also obvious that in the case of grease lubrication and where seals may not be as efficient as preferred, lubricants may be contaminated with dirt. In such cases it is, therefore, advisable to thoroughly clean the bearing parts. This can best be accomplished by having several tanks similar to Figure 19 which are provided with steam heating coils. The first of these tanks should be filled sufficiently with a No. 28 paraffin oil having a viscosity of 100 seconds at 100 F. This oil is lighter than an SAE No. 10. This oil should be heated to approximately 300 F. It will be noted that the steam heating coils are located on the faces of the tank and that the bottom of the tank is provided with wood racks. The bearings are then allowed to remain in this oil a sufficient amount of time to thoroughly melt down all the grease that clings to the various raceways. It is found practical to provide a light agitation to the oil in the tank in order to help dissolve the grease.

If it is found that the grease to be removed is quite heavy and if a lot of corrosion has occurred, an alkaline solution can be made from three or four ounces of trisodium phosphate dissolved in each gallon of water. As an alternative to this, a very effective dissolvent can be made by using sodium meta-silicate using approximately one ounce per gallon.

After the old lubricant has been thoroughly melted from the bearing, the bearing is then removed from this tank and placed in another tank which should be

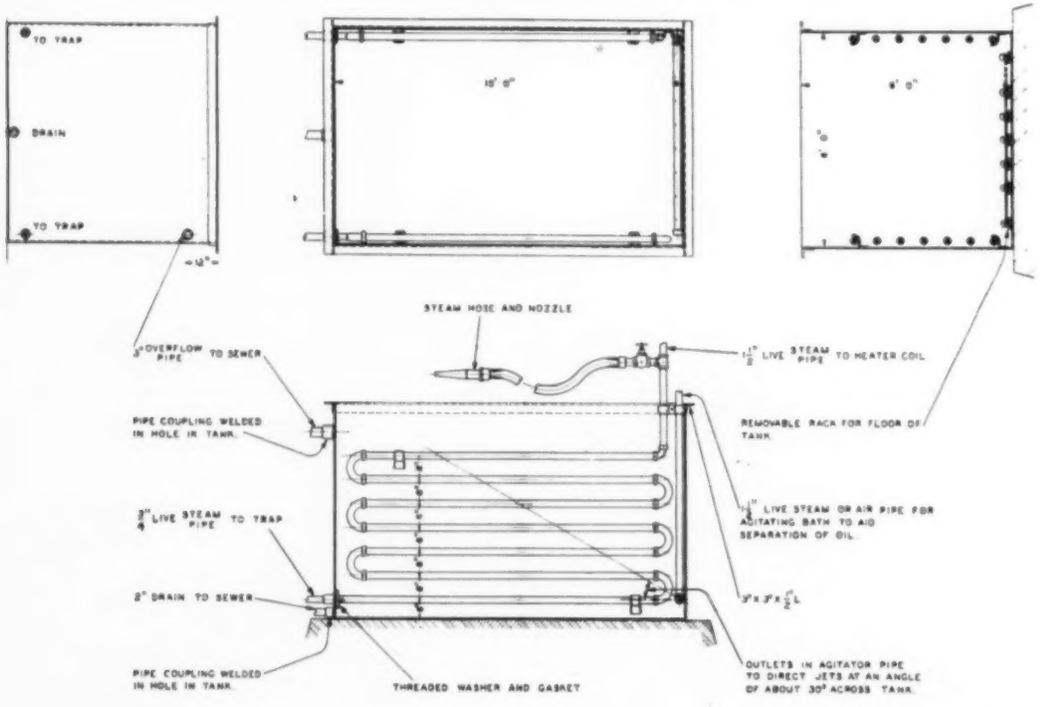

TO TRAP
DRAIN
TO TRAP
STEAM HOSE AND NOZZLE
TO SEWER
TO HEATER COIL
PIPE COUPLING WELDED IN HOLE IN TANK
REMOVABLE RACK FOR FLOOR OF TANK
TO TRAP
LIVE STEAM OR AIR PIPE FOR AGITATING BATH TO AID SEPARATION OF OIL
DRAIN TO SEWER
PIPE COUPLING WELDED IN HOLE IN TANK
THREADED WASHER AND GASKET
OUTLETS IN AGITATOR PIPE TO DIRECT JETS AT AN ANGLE OF ABOUT 30° ACROSS TANK

Figure 19—Water-tight tank is used for cleaning bearings.

filled with soluble oil at approximately 190 F temperature.

After the bearings have then been carefully inspected and a decision has been made that the bearings are ready for further use, it is recommended that the bearing be dipped in a tank of hot petrolatum at 190 F or light machine oil at normal room temperatures. This oil coating will protect the various surfaces of the bearings until they are again placed in service. The bearings should be stored in properly protected boxes or bins and be given the same care that is given a new bearing received from the bearing manufacturer.

Bearing repairs—If an inspection shows that some spalling has occurred on the rollers, but none on the raceways, it may be advisable to replace the rollers with others of an exact size. Assistance in doing this work is readily available through our service engineers, or the entire bearing may be returned for repair. If the spalled roller is to be replaced at the mill, the defective roller as well as one or two of the adjacent rollers should then be returned to us for replacement. The good rolls will enable us to make the necessary measurements required to supply new rollers of the exact size required. Each roller assembly is marked to indicate the size of the rollers when new and it is important that the replacement rollers be reassembled in their proper position. It is very rare that a bearing indicates a complete failure of all parts. In some cases where the bearing goes through a very bad wreck, it may also have passed its expected life. However, in most cases periodic inspection and repair of the bearing prolongs the total life that will be obtained and thereby reduce the overall bearing cost to a minimum.

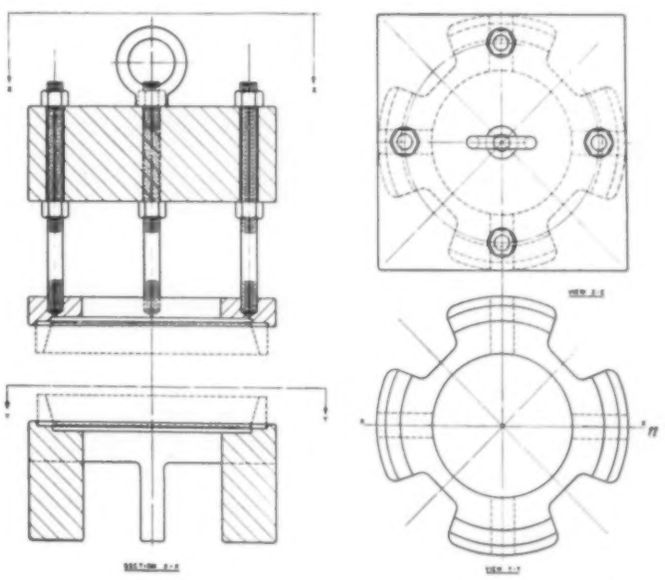
Load zones in cups—In the forepart of this paper we mentioned that the outer races of our back-up roll bearings are marked to show four load zones viz. 1, 2, 3 and 4. Before the roll neck bearing is removed from the chuck, an examination of the cup face will reveal whether the loading was on Zone 1, 2, 3 or 4. If the cups were so arranged that the load zone was in Zone 1, then this should be noted and the cups turned to Zone 2 if the bearing is reapplied in the chucks. This is rather important since the cups do not rotate and, consequently, the load is somewhat concentrated on approximately one-fourth or 90 degrees of the race section. If signs of surface fatigue or light spalling is noted during such an inspection, the spalled or fatigue spots should be touched up with a small pencil grinder and the cup rotated to the next zone for the next service life. In the event that the spalling is extensive over 90 or more degrees of the circle of cup contact, then it might be advisable to return the entire bearing to the manufacturer for a major overhaul or repair.

Bearing readjustment—A shim type adjustment is many times used in the two-row type "TDI" bearings. In some cases their lateral is established with cup spacers. However, four-row bearings are invariably set by means of spacers. Due to the weights of parts, special fixtures are recommended for use when checking the bearings for readjustment. During the original production of the bearing, the races are perfectly round and the practice of measuring each individual part is used. By a tabular calculation we then obtain the actual space readings for the cup spacers "B" and "D" as well as the cone spacer "C." However, this requires special checking equipment and is not always available by the bearing user. In setting a four-row bearing on its cups in a vertical position such that the axis of the bearing cone and roller assembly is in a vertical position, the rollers in the bottom position as well as those in the next to the top row carry the weight of the individual parts. However, the rollers within each of these cage assemblies tend at the same time to drop away from the cone rib. As a contrast to that, the top row of rollers as well as the third row of rollers from the top will tend to drop freely against the adjacent cone ribs due to their own weight. Since the bottom row of rollers and the row of rollers next to the top do not provide this possibility, it is necessary to place a weight equal to the bearing weight, on the bearing to help to force these rollers up against the rib. While this is being done, the bearing should also be rotated in each of the raceways to be certain that the rollers will work against the cone ribs.

A second reason for using the weight system is the fact that the races in the bearings tend to go slightly out of round during service. This is due to the loose fit of both cones and cups in practically all roll neck applications. The races will tend to take the shape of the chuck bore or neck outside diameter as the case may be. In the case of the chuck bores, we find that these also sometimes tend to go out of round during service or distort due to the heavy loads imposed by the bearings. By applying a weight approximately equal to the weight of the bearing being checked, the various parts within the four-row bearing tend to become seated and, therefore, a more accurate measurement of the various spaces can be obtained in order that spacers can be properly ground to suit the worn conditions.

Figure 20 is a bearing assembly jig which has proved quite satisfactory. This fixture is designed to accommodate blocks of varying weights which depend upon the size and type of bearing being adjusted. When regrinding the spacers on four-row or two-row mill type

Figure 20 — This bearing assembly jig works very satisfactorily.



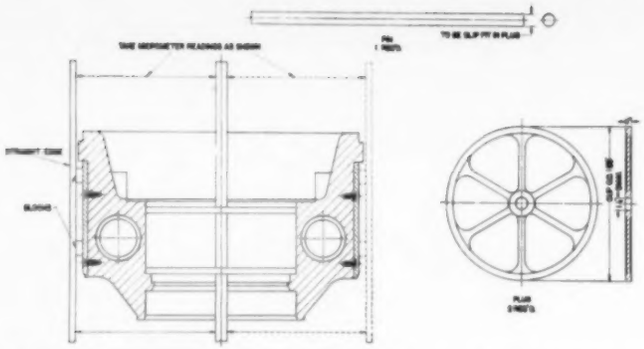


Figure 21 — Roll chuck checking fixture checks accuracy of outside faces of chuck with the inside diameter.

bearings, it is advisable to remove the space and spacer measurements recorded on the respective parts. When reassembling a bearing, care should be exercised to see that the parts are properly assembled in the sequence indicated by the lettering system on the parts. The fixture in the larger sizes is provided with an "I" bolt in order that it can be readily removed from the bearing with a suitable crane.

Bearing set-up—roll necks — The cup and cone spacers which are furnished with the original type "TQO" or "TDI" bearings are ground by the manufacturer to provide proper running laterals within the bearings due to such conditions as internal bearing temperatures, etc. It has been found that some wear also occurs on the cone O.D., cup I.D. and rollers, and that corrections should occasionally be made in the spacers to compensate for this wear. It is believed that the cone and cup spacers should be reground to the original bearing setting as recommended by the manufacturers when the looseness from wear and stretch of the races is greater than approximately 1.5 times the original setting. As an example, if the bearing is originally provided with 0.008 in. end play in two rows, the bearing spacer should be reground when this looseness is 0.012 in.

Figure 21 shows a mill roll chuck checking fixture which will check the accuracy of the outside faces of the chucks with the inside diameter of the chuck. Having two plugs separated by means of a pin and then measuring the distance between the straight edge located on the face of the chuck and the pin O.D., it is found readily possible to determine whether any inaccuracy on the chuck sections occur. This same principle can be used not only on work rolls and back-up rolls, but other bearing boxes as well.

Steel mill roll chucks are obviously subjected to a great amount of rough handling of various kinds and will tend to distort and pound out not only on the faces, but in the bores as well. This is practically unavoidable during assembly and disassembly in the mill stands. It is rather obvious that the more wear that occurs on these faces, the more inaccurately the bearing will be lined up with the mill housing or its mating bearing on the other end of the mill roll. For that reason chucks should be inspected at frequent intervals and rebuilt or remachined as necessary in order to gain full advantage of the capacity of the bearing to do its work and to maintain better mill operating characteristics.

The fixture in Figure 22 uses a plug which will have an outside diameter equal to the outside diameter of the cup. After the plug is clamped to the chuck and the entire unit set on a planer, the chuck faces may be replaned by setting the tool to clear the pins by approximately 0.003 in.

LUBRICATION

General—The roller bearing operates practically without heat or wear and is particularly adapted to high speeds where the speed range is within certain limits. In the case of plain bearings, the ability of the bearing to operate at high speeds depends strictly upon the maintenance of an oil film which has its limitations at the low operating speeds or where a reversing operation is involved. The ability of the tapered roller bearing to operate at higher speeds depends obviously upon the type of lubricant which is used and the method used in lubricating the bearing.

Proper lubrication is essential to all types of bearing applications whether they be journal or of the anti-friction type. The kind of lubricant used is governed by the design and operating conditions. Since the fields of use for anti-friction bearings are steadily on the increase, it is quite natural that the number of unusual lubrication problems also are on the increase. In spite of the fact that the same type of lubricant may be used in many applications, the lubricant manufacturers realize the importance of development and, therefore, are quite progressive in that many synthetic and more stable products have been developed for some of the more special applications. Lithium soap and barium soap greases are becoming quite common for those jobs requiring unique properties and where these products justify the higher cost of the lubricant. For higher temperature applications, silicones and silicone greases have been used and show improvement over the usual high temperature lubricants. The large volume of applications is, however, still taken care of by standard well refined mineral oils and the standard lime soap and sodium soap greases.

The function of lubricants for tapered roller bearings is quite similar to that for any type of anti-friction or plain bearing in that they reduce friction, carry away heat, protect bearing surfaces from corrosion, and aid the seals in keeping foreign matter out of the bearings. In the case of the reduction of friction, it is obvious that the lightest bodied oil will undoubtedly show the lowest bearing friction, however, the extreme pressure additives aid in decreasing this friction for a given bodied oil. In the case of grease, good lubrication depends upon whether the lubricant is a channeling type and whether its oil bleeding ability under certain operating conditions will feed a minimum of light oil to the bearing surfaces.

Higher bearing temperatures may be due to overloading from insufficient bearing size, overloading from distortion of weak housings, too much lubricant and too heavy lubricants. There are, of course external heat sources which in most cases cause more difficulty with bearing temperatures than those temperatures

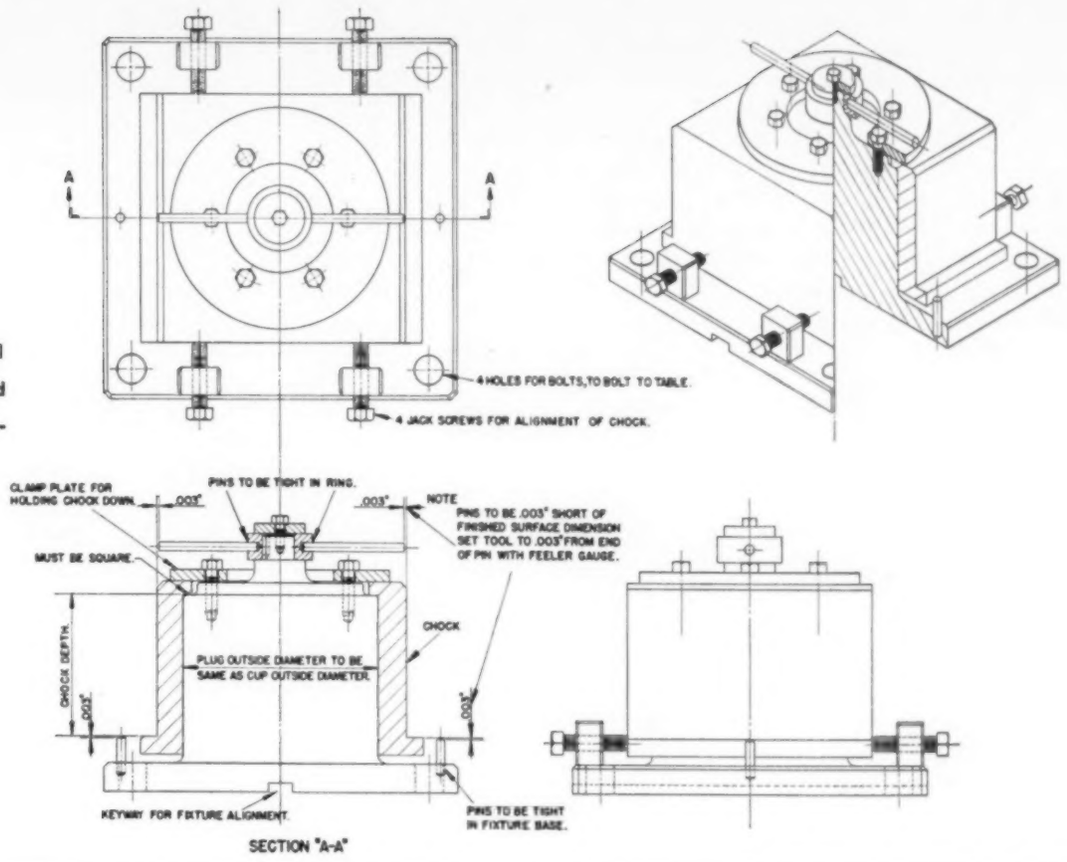

A
A
4 HOLES FOR BOLTS, TO BOLT TO TABLE.
4 JACK SCREWS FOR ALIGNMENT OF CHOCK.
CLAMP PLATE FOR HOLDING CHOCK DOWN.
.003"
PINS TO BE TIGHT IN RING.
.003"
NOTE
PINS TO BE .003" SHORT OF FINISHED SURFACE DIMENSION SET TOOL TO .003" FROM END OF PIN WITH FEELER GAUGE.
MUST BE SQUARE.
CHOCK DEPTH
.003"
PLUG OUTSIDE DIAMETER TO BE SAME AS CUP OUTSIDE DIAMETER.
CHOCK
.003"
KEYWAY FOR FIXTURE ALIGNMENT.
PINS TO BE TIGHT IN FIXTURE BASE.
SECTION "A-A"

Figure 22 — Steel mill roll chucks should be checked frequently.

generated by the operation of the bearing itself. This is especially true in the case of the higher speed applications in which rubbing type seals are employed In the cases of worm drives where high surface speeds are involved, a temperature built up from the action of the bearing must be considered in the selection of not only the bearing but also the type of lubricant and mounting employed.

High temperature conditions are likely to cause foaming and separation of soap and oil, particularly when the greases contain moisture. The oil may drain out, leaving only the heavy soap in the housing. When this occurs, the lubricating value of the grease is seriously affected and it is advisable to clean out the bearing and housing and start over using just enough grease. When a lubricant is subjected to high temperature under operating conditions, special lubricant should be used. Greases when operating under such conditions should be of such a character that they will return to their original consistency when the bearing cools. In cold operating conditions, bearing rollers or gears will merely cut a channel through a stiff oil. This is particularly serious when the bearing lubrication is dependent upon splash from the gears. The installation of a steam coil into the gear case to thin out the lubricant in cold weather has been used in certain cases. If lubricants are properly selected for such rare cases, provisions for separate heating systems will obviously be unnecessary.

In dry rolling, temperatures of 250 to 300 F have been reached. A special high temperature extreme pressure grease is usually used in such applications. However, the use of a full circulating oil system can serve a very useful purpose on this type of job in that it will serve to neutralize the bearing temperatures and also will provide a method through which the carbon sludge which is formed can be properly filtered out.

From the standpoint of bearing corrosion it should be borne in mind that the highly polished surfaces of anti-friction bearings are easily attacked by rust or corrosion. The lubricant must prevent this attack and maintain a smooth surface so essential to friction-free operation. During shipment and in storage the bearing surfaces are very carefully protected with a coating of oil by the manufacturer. After installation, it is the function of the lubricant to maintain the rust and corrosive proof coating on the operating surfaces at all times.

A word of caution to the operating men would lie in the fact that they should select their lubricants very carefully to see that they are always up to specifications for their intended application. The chemical laboratory can be of great value to the operating or maintenance department in this connection.

The importance of the amount of lubricant which should be used in any specific application cannot be overstressed. There is a fallacy in believing that in order to assure the best lubrication for a bearing, we should use the greatest amount. Too much or too heavy a lubricant, if incorrectly used, will cause an increase in temperature caused by the churning action of the bearing in the lubricant which is usually followed by lubricant leakage out through the closures. An attempt to stop this lubricant leakage by tightening the closures will increase the friction, thus still further aggravating the condition until an extreme case of temperature occurs which might lead to bearing failure.

With the use of tapered roller bearings, a cleanliness factor as well as a bearing temperature factor is very nicely provided by the feature of the taper of the rollers. Oils will naturally tend to flow from the front face of the cone to the back face of the cone due to the centrifugal action of the roller and cage assembly about the shaft. Due to the natural taper of the cup, the oil tends to flow towards the large end of the rollers and if provisions are made for circulation slots in the housings around the bearings, a full circulation system is provided around each row of rollers. This not only tends to assist in the lubrication of the bearing, but would also tend to pull any foreign particles or dirt through the bearing and clear it through the cavity between the two rows of rollers. This tapered design feature is unlike some anti-friction bearings where a concave outer race is sometimes prevalent which will act as a natural trap to maintain the foreign particles within the trap for a considerable period of time and thereby cause lapping of the bearing parts.

Extreme pressure lubricants — The introduction of extreme pressure lubricants dates back to the advent of the continuous 4-Hi mills. It was found that the pinions driving the work rolls are limited in size with the consequent high unit pressures on the gear teeth. At the high pressures involved, normal lubricants were inadequate and were not providing sufficiently strong oil films. This situation was saved by resorting to extreme pressure additives in the lubricants thus giving from five to seven times the film strength of the normal lubricant. In the case of roll neck bearings, greases containing extreme pressure ingredients are also used. It can be generally stated that the relationship between extreme pressure lubricants and straight mineral products is not unlike the relationship between alloy steels and straight carbon steels. With the addition of sulphurized or chlorinated additives to carefully selected oils, a satisfactory extreme pressure lubricant can be obtained giving over 45 pounds on the Timken wear and lubricant testing machine without scoring either the rotating cup or the test block. The same general principle applies to non-fluid lubricants for heavy duty roll neck bearings for both back-up and work roll positions. A lime base type grease is normally preferred although at the higher operating speeds where temperatures may go to 200 F or higher, high melting point type grease of sodium or lithium base must be used. Greases should pass a 35 pound minimum test on the Timken lubricant testing machine.

Grease lubricated applications—A great many of the applications in steel mills permit the use of grease lubrication. Grease should always be a smooth well manufactured product composed of a high grade soap and refined filtered mineral oil. It should be free from corrosive matter, grit, rosin, waxes, talc, mica, graphite, clay or other fillers of any kind. All bearing boxes should be filled about two-thirds full with grease. In some installations where extreme dirt conditions are involved and where speeds are low, it is well to apply more lubricant within the bearings, being certain that the grease enters the mid point of the bearing and is free to work out through the bearings and out through the closures. This not only replaces the contaminated lubricant that may be within the bearing box, but also tends to maintain top closure efficiency.

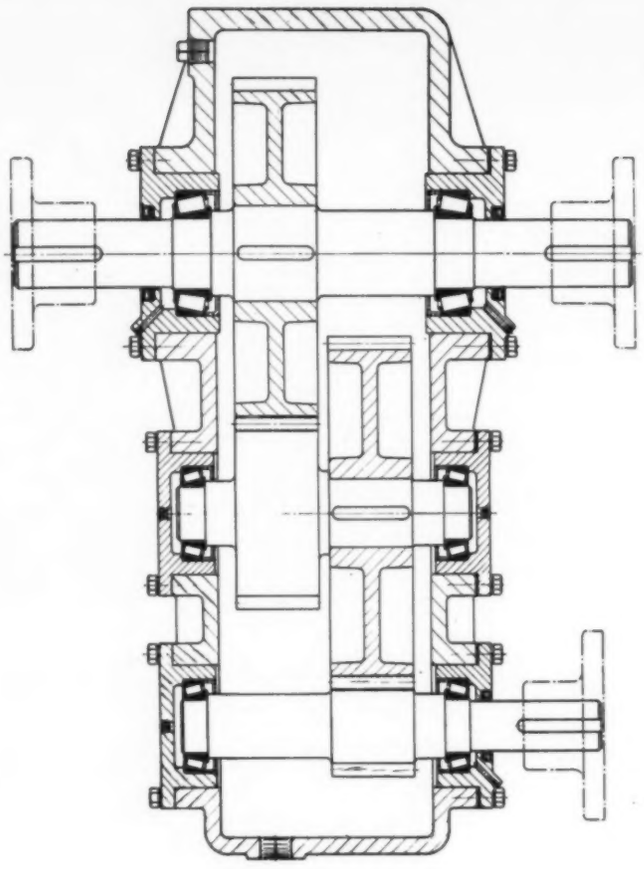


Figure 23 — Crane gear case.

The use of a non-fluid lubricant results in major savings not only in the original cost of the type and amount of lubricant, but also in the reduction of cost of its application.

On low speed jobs it is acceptable to pack the bearing box completely full of grease. This will obviously tend to reduce the void within the bearing chamber and will reduce the possibilities of moisture forming within the bearing. In other cases where the speeds are somewhat higher, the bearing box void is usually filled from one-third to one-half full with lubricant.

In applications which operate at the higher speeds, temperature rise will occur in the bearing boxes with the result that any air that is trapped within the bearing box will expand and create internal pressure within the bearings. This often leads to failure of the seals and also causes still further increases in bearing operating temperatures. It has been found practical to provide relief fittings in all bearing boxes in order to relieve the internal pressure. This is not only recommended in the case of grease lubrication but it has also been found practical to provide breathers in gear cases in which oil is used in order to provide for this same type of relief from internal temperatures within the gear boxes.

Grease lubrication is satisfactory up to certain limits and is usually satisfactory up to a point where the temperature of the bearing or roll neck is below the critical

temperature for lubricant breakdown. When greases tend to break down, the oil separates from the soap which develops carbonization which in turn quite readily causes lapping of the bearing parts.

FLUID LUBRICATION

Oil dams—Figure 23 shows a crane gear case. In the usual gear case where lubricant is supplied to the gears, the consistency of the lubricant is invariably sufficiently light to provide lubrication for the bearings as well as the gears. Since these are usually fluid lubricants, splash from the gears will usually provide sufficient lubrication to the bearing. However, if the speeds are low or the shafts are placed vertically above each other, there is considerable danger that the bearings in the top shafts may not receive sufficient splash from the gearing and therefore, fail from lack of lubrication. In such cases two provisions may be made. The one is that a full circulation system be provided with the lubricant not only leading to each of the bearings, but also over the gearing. This circulating system can be broken down into two categories each of which is relatively important. One is that the bearings be provided with oil dams to maintain a constant oil level through the bearings at all times. With the provision for an oil dam, the pumping arrangement for the circulating oil system may be tied in to the unit such that the pump starts up when the gear drive starts turning. If these oil dams are not provided and if the speeds are relatively high in the critical shafts, the time lag between the instant when the unit starts up and that time when the lubricant finally reaches the bearings may be sufficient to cause faulty bearing lubrication.

Where oil dams cannot be provided for some constructional reason, it is important that the oil pump be separately driven by a separate motor which is provided with proper electrical controls to assure that the motor for the oil pump is turned on before the motor for the gear drive is turned on.

Oil having a viscosity of approximately 90 to 150 seconds at 210 F is satisfactory for the average case.

In the case of gear drives it is advisable to flush out the bearings with kerosene or light machine oil at approximately one year intervals to help to wash out any sediment which might have collected and which has not been drained out by the circulating oil system, where a circulating oil system is used. Likewise, if the machinery is inactive for any length of time, the lubricant should be removed from the bearings and replaced with fresh grease or oil, as the case may be.

Table V shows lubricant specifications which are usually required in mill equipment. These are all of the extreme pressure type.

TYPICAL CIRCULATING OIL SYSTEMS

Hot and cold saws—Figure 24 shows the use of the "TS" type bearing mounted on a hot saw spindle. Two bearings are used at each end properly set by means of cup and cone spacers. The cone spacer is a plain solid spacer whereas the cup spacer is provided with a milled slot across its outside diameter adjacent to the oil entry point and is provided with holes which will lead the oil from the cavity of the slot to the cage of the bearing.

TABLE V

HEAVY DUTY LUBRICANT APPLICATIONS

Operating temperature	Moisture present		No moisture	
	Oil	Grease	Oil	Grease
Below 32 F			Extreme pressure oil viscosity 75 sec to 100 sec @ 210 F Saybolt Universal. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Extreme pressure grease; lime or soda base. Consistency Karns-Maag method 30.0 mm to 45.0 mm @ 75 F. Load capacity minimum 33 lb lever load. Timken lubricant tester.
32 F to 125 F	Extreme pressure oil viscosity 100 sec to 175 sec @ 210 F Saybolt Universal. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Extreme pressure water resistant grease. Consistency Karns-Maag method 20.0 mm to 30.0 mm @ 75 F. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Extreme pressure oil viscosity 100 sec to 175 sec @ 210 F Saybolt Universal. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Extreme pressure grease; lime or soda base. Consistency Karns-Maag method 20.0 mm to 30.0 mm @ 75 F. Load capacity minimum 33 lb lever load. Timken lubricant tester.
125 F to 180 F	Extreme pressure oil viscosity 100 sec to 250 sec @ 210 F Saybolt Universal. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Extreme pressure water resistant grease. Consistency Karns-Maag method 15.0 mm to 25.0 mm @ 75 F. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Extreme pressure oil viscosity 100 sec to 250 sec @ 210 F Saybolt Universal. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Extreme pressure grease; lime or soda base. Consistency Karns-Maag method 15.0 mm to 25.0 mm @ 75 F. Load capacity minimum 33 lb lever load. Timken lubricant tester.
Above 180 F	Extreme pressure oil viscosity 175 sec to 250 sec @ 210 F Saybolt Universal. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Not recommended.	Extreme pressure oil viscosity 175 sec to 250 sec @ 210 F Saybolt Universal. Load capacity minimum 33 lb lever load. Timken lubricant tester.	Not recommended.

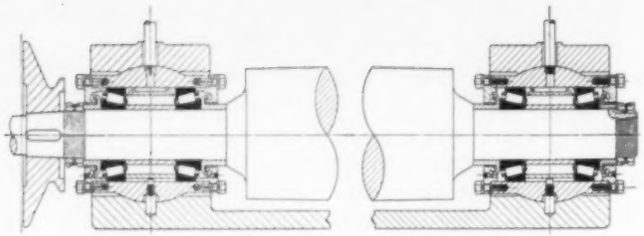
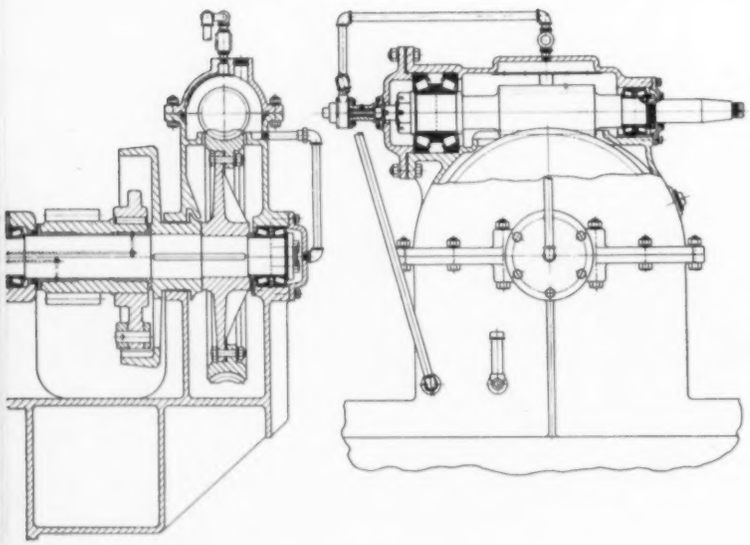


Figure 24 — Bearing is mounted on hot saw spindle.

This spacer is locked against rotation by means of a set screw which is fitted into an axial groove on the O.D. of the cup spacer. The oil is then drained out through each end cap and returned to the oil supply. The bearings on the saw end of the arbor are held in place through the outer races by means of the cup followers. The bearings on the opposite or floating end are provided with ample clearance to permit the cups to float in the self-aligning box in which the bearing is mounted. The self-aligning type box construction is highly recommended in an installation of this kind due to the very high vibration which is developed by the rotation of the saw and due to the relatively high tensile loads applied by the belt drive. This type of bearing and mounting is also used in the case of cold saws in which peripheral speeds of 25,000 to 28,000 fpm are quite common. By using a self-aligning type of box construction it permits a minimum of looseness within the closure elements, thereby assuring a very efficient closure with the added provisions of full self-alignment. It will be noted that the flingers which are located on the inside faces of the cup followers and adjacent the back faces of the cones are provided with a horizontal lip, which is permitted to work with a close radical clearance over the outside diameter of the inner cup follower boss.

Figure 25 shows an external lubrication system which leads the oil from the bottom of a crane gear case to a pump driven by the worm shaft and then through suitable pipes to provide lubricant not only to the worm drive but also the bearings as well.

Figure 25 — External lubrication system shown lubricates not only the worm drive but also the bearings.



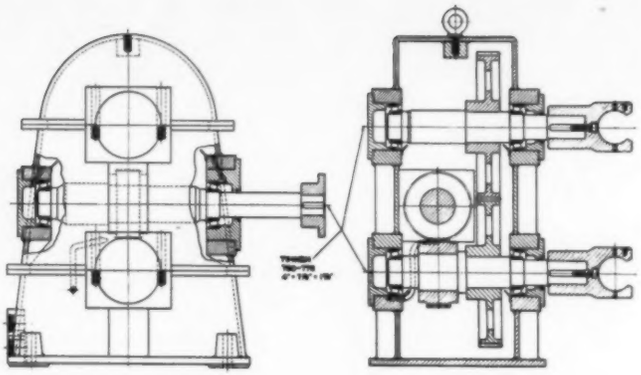


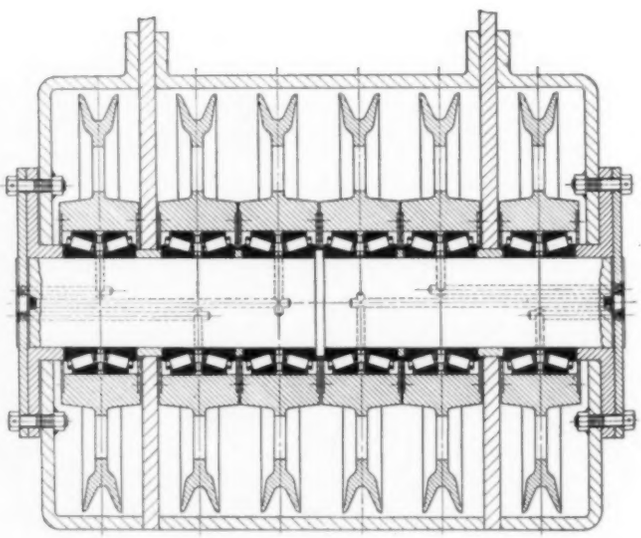
Figure 26 — Application of bearing to pinch roll drive for flying shear.

MOUNTINGS

Type "TS" bearings—Figure 26 shows the application of this type of bearing to a pinch roll drive for a flying shear on which a pair of bearings are used on each shaft. Bearings are properly set by means of thin metal shims and a circulating oil system is used to properly lubricate the bearings. In the left hand view, splash dams are indicated which catch the oil from the splash of the gears and lead it to the end cap on the blind end or cup carrier on the coupling end. The oil is therefore carried through the bearing to provide ample lubrication. The sectional drawing on the right side of the figure shows oil dams in the bottom positions in order that oil which is splashed from the gearing will flow along the gear case inner face and fill these dams with oil, thereby assuring ample lubrication to the bearings at all times. In some cases circulating oil systems are used.

Type "TNASW" and "TNASWE" mountings—Fig-

Figure 27 — Bearing mounted on 6-sheave block.



ure 27 shows the type "TNASW" bearings mounted in a 6-sheave block. The bearing is protected from the elements by means of a sheet metal cover bolted to each face of the sheave hub. Figure 28 shows the type "TNASWE" bearing which provides for lubrication of the bearing through rifle drilled holes and grooves on the inside faces of the cones, but unlike the previous Figure 27 the closures are allowed to run with a relatively close clearance on the outside diameter of the bearing cone rib. In this particular instance the bearing cones are merely clamped together on the sheave pin, since proper bearing lateral is built into the bearing when it is manufactured. This provides for a more

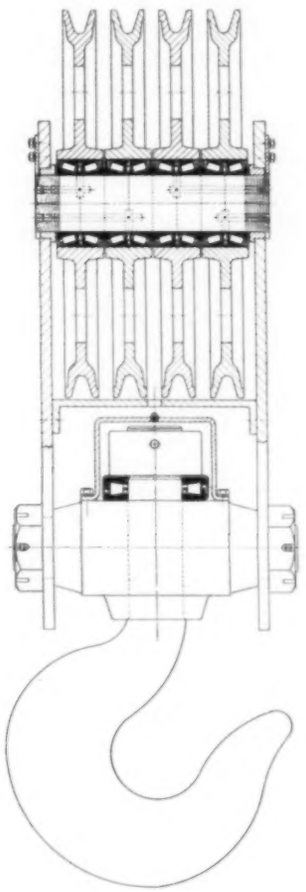


Figure 28 — This sheave bearing mounting provides for lubrication of bearing through drilled holes and grooves on the inside faces of the cones.

compact mounting, inasmuch, as the overall width of the block can be held to a minimum. This overall width is clearly indicated. A thrust type bearing is used on the crane hook.

Figure 29 shows how our "TNASWH" bearing is mounted in the back-up rollers of levelers. It will be noted that the outside diameter of the cup is made large in order to get a heavy section. The cup outside diameter then serves as the loading ring, thereby carrying the levelling loads directly into this race. This provides the full bearing capacity with a minimum roller outside diameter.

The bearing is a unit assembly built in the factory for correct running clearances and includes seals to retain the lubricant. Lubrication is provided for by the use of slots and grooves at the front faces of the cones on the vertical center line of the bearing.

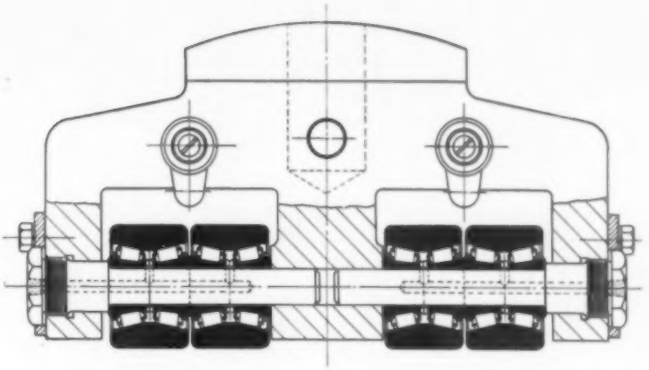
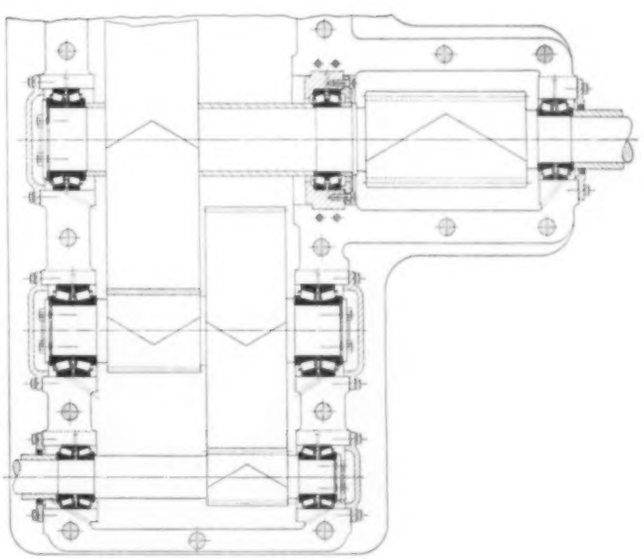


Figure 29 — Illustration shows use of bearings in backup rollers of levelers.

Gear drive bearings—Figure 30 is a mounting showing the application of bearings to a double helical gear combination drive and pinion stand. Two-row type bearings are used in all positions. One two-row type "TDI" bearing in the center position of the top shaft locates the shaft in both radial and axial directions, whereas, the balance of the bearing are two-row type "TDO" mounted with the cups free to float. The bearings in the first and second shaft positions can be selected to give equal outside diameter to simplify boring operations. The bearing in the output end of the mill pinion end is mounted in a carrier whereas the fixed bearing in the center position is mounted in a cartridge. These housings are split and, therefore, assembly can be readily obtained.

The above drive design has been used for many years quite successfully in many applications. With the advent of higher mill speeds, a number of problems have arisen which are steadily provided for by rearrangement of the design as shown. One of the arrangements consist of mounting the various bearings in a hardened sleeve in order to reduce any tendencies for the bearings to pound into the gear case. Where gear cases are

Figure 30 — Double helical gear drive and pinion stand.



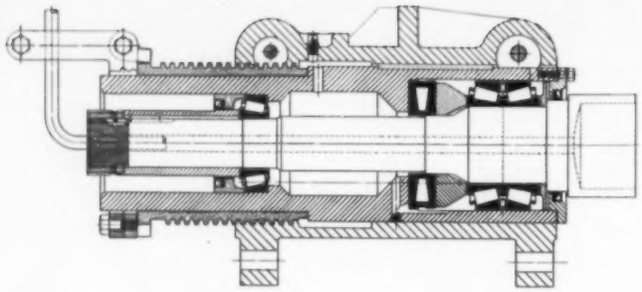


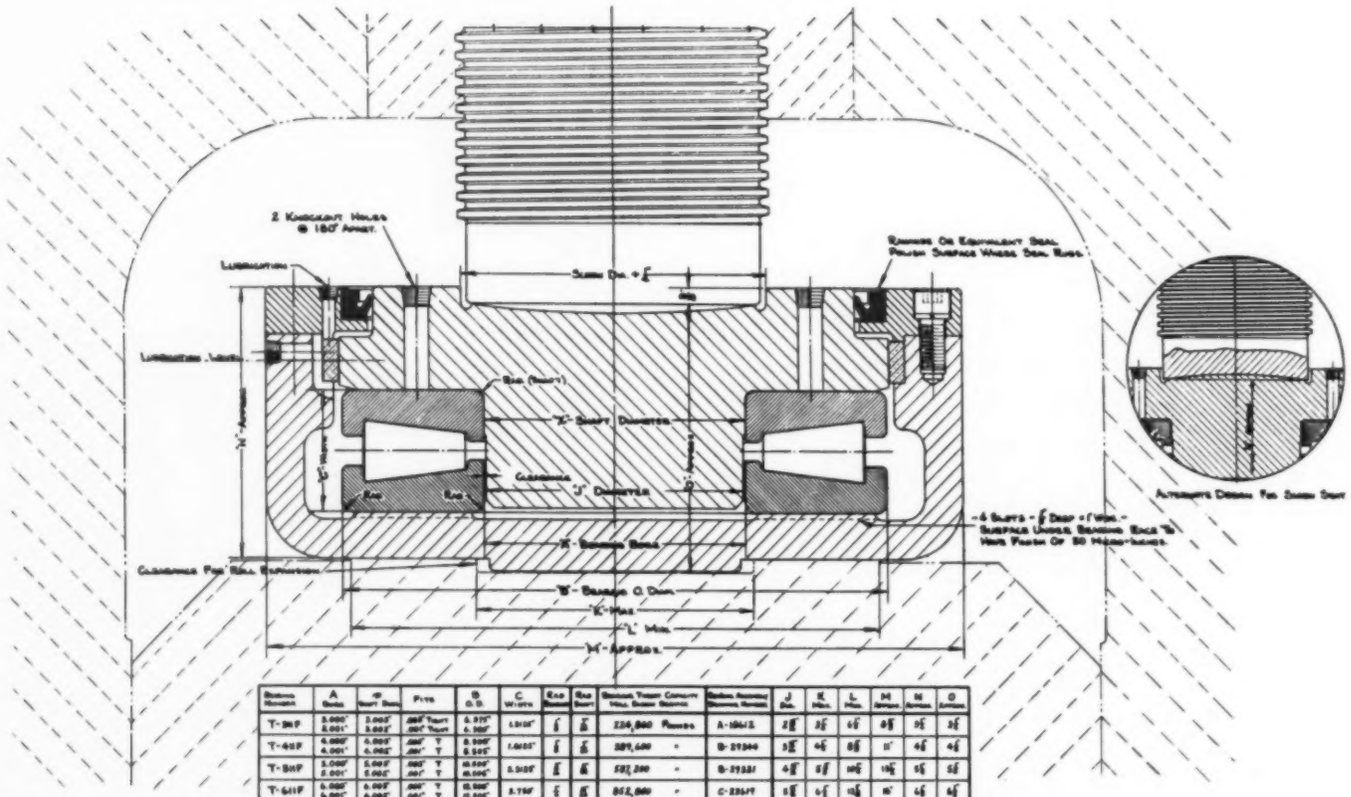
Figure 31 — Arrangement for applying bearing on piercing mill thrust block.

of sufficient hardness, this pounding action will not normally occur. However, it is sometimes found more economical to mount the cups in cartridges and then in turn clamp the cartridges in the gear housing than it is to provide the necessary hardness in the housing in order to withstand the terrific shock loads that are prevalent in many of these bearing positions. In other applications where extremely high speeds are involved and where the normal gear loads are opposed to the gear and shaft weights, we obtain a lifting and dropping action of the bearing assembly in combination with high rotative speeds. In such cases it has been found practical to either mount the cups with a tight fit and float the cartridges or to use wider outer races in the bearings.

Thrust bearings type "TTHD"—Figure 31 shows the arrangement that is used in applying our "TTHD" type bearing on piercing mill thrust blocks. The flat type thrust bearing carries the predominant thrust load in this installation providing a rigid support for the high thrust loads encountered. The thrust bearing is properly set into the block by means of the single row TS bearing on the left end of the figure with the use of two nuts and a tongued washer. The bearing adjacent the nose end of the block is free to float in the bore of the block. Bearings of this type which carry very heavy thrust loads are precision built, on apex, and are accurately run in to get properly matched races. These bearings can operate at relatively high speeds as is evidenced by the fact that some of these installations operate at intermittent speeds upwards to 1200 rpm. In an installation of this kind, an extreme pressure type fluid lubricant is recommended.

Figure 32 gives a tabulation of thrust bearings recommended for use under the screw-downs. The tabulation includes the screw rating for each bearing size. The use of the assembly permits the use of smaller screw-down motors for specific mill loads and at the same time permits a more responsive adjustment control due to the very high efficiency. Many of these

Figure 32 — Recommended application of thrust bearings under screw on screwdown.



T-3HP	3.000" 3.001"	3.003" 3.003"	.000" Thrust .000" Thrust	6.875" 6.500"	1.0938"	1	1	230,800 Pounds	A-10615	2	2	4	0	2	2
T-4HP	4.000" 4.001"	4.003" 4.003"	.000" T .000" T	8.500" 8.500"	1.4688"	1	1	389,600 "	B-29344	3	4	0	11	4	4
T-5HP	5.000" 5.001"	5.003" 5.003"	.000" T .000" T	10.000" 10.000"	2.1250"	1	1	582,200 "	B-29331	4	5	10	14	5	5
T-6HP	6.000" 6.001"	6.003" 6.003"	.000" T .000" T	12.500" 12.500"	2.750"	1	1	852,800 "	C-22649	5	6	12	16	6	6
T-7HP	7.000" 7.001"	7.003" 7.003"	.000" T .000" T	15.500" 15.500"	3.250"	1	1	1,199,000 "	C-22651	6	7	14	18	7	7
T-8HP	8.000" 8.001"	8.003" 8.003"	.000" T .000" T	16.500" 16.500"	3.625"	1	1	1,456,000 "	A-4834	7	8	16	20	11	7
T-9HP	9.000" 9.001"	9.003" 9.003"	.000" T .000" T	19.000" 19.000"	4.250"	1	1	1,752,000 "	C-22652	8	9	18	22	9	8
T-10HP	10.000" 10.001"	10.003" 10.003"	.000" T .000" T	20.750" 20.750"	5.375"	1	1	2,220,000 "	E-16340	10	10	20	28	11	10

bearings are in use on both new and change-over jobs.

GENERAL INFORMATION

In taking heavy reductions or in rolling wide widths of material, it is extremely important that the bearings give free rolling under all combinations of speed and load. This feature is amply permitted in the roller bearing equipped mills since the rolling resistance of a loaded roller bearing is practically the same regardless of whether its rotation is continuous or whether it is subject to reversal. This leads to reduction in scrap material in the case of reversing type mills since the reversal in rolling may be accomplished without changing the pressure on the rolls and without the constant danger of marked mill rolls caused by slippage from a bearing, which is not free from drag throughout its entire two directional speed range.

Provision must be made to hold mill rolls in a definite and accurate position and this can be quite readily accomplished by the use of tapered roller bearings since it will permit a minimum of axial as well as radial movement of the rolls. This is also accomplished without the use of any auxiliary thrust unit or thrust bearing. A plain type bearing obviously requires certain running clearances to maintain a proper oil film, in turn, will cause a variation in the maintenance of the vertical pass dimension. If the rolls, are heavily preloaded, then it becomes more difficult to maintain the proper oil film. The operating temperatures, which are the result of plain bearing friction and those passed back from the material in contact with the mill rolls cause a rapid change in the clearances which, according to their mere nature, are critical. Special thrust units, either as separate units or as units with the bearing chuck, require wider bearing housings. The use of the tapered roller bearing presents the advantage of obtaining perfect alignment in the setting of the rolls in both radial and axial directions and maintains this setting for longer periods of time and without constant readjustment. It is also possible, by proper design, to make provision on the mill for adjusting devices which will permit setting the rolls or changing the setting by small increments in minimum of time and without the cut and try method used with plain bearings. Once adjusted, the operator can be sure that the rolls will hold their setting, and in most cases the only adjustments which he need consider are those required to compensate for wear in the roll passes.

Machine work—It is exceedingly important that machining tolerances as set up by designing engineers be strictly adhered to, not only at the time that the machine is originally built but also during possible subsequent repairs made to the machine involved. The importance of bearing cone and cup fitting practice cannot be over emphasized since failure to follow the recommended tolerances as prescribed by the bearing manufacturer may at times cause difficulty in the field. There are cases, of course, where the manufacturers or builders have, for some reason, not followed the exact recommendations of the bearing manufacturer due to an experience factor of their own. In many cases these variations to standards are forced upon the manufacturers due to some design characteristics and would not normally cause difficulty with the bearings. In other cases, however, failure to follow exact standards may lead into difficulty and for that reason the machine user would do well to check this with either the manufacturer of the machine, or the manufacturer of the bearing which is involved. By taking this double check they will determine the exact reasons for the variations involved or under some remote cases may even uncover variations that are not acceptable that may need corrections.

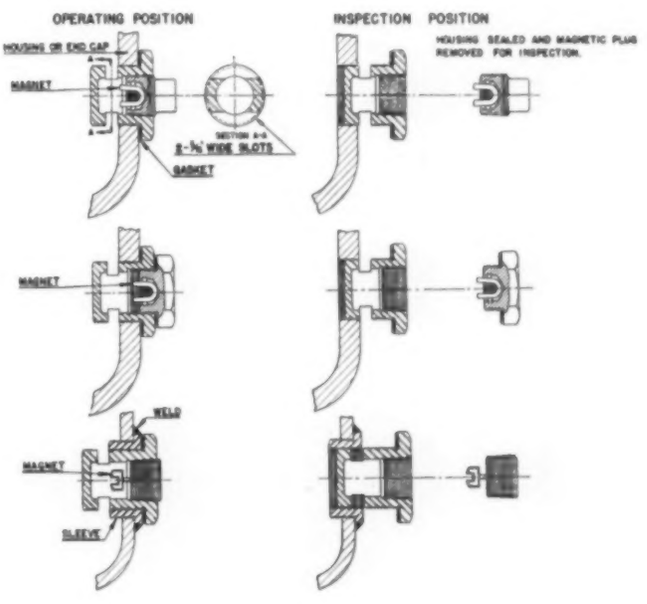
The space between the cone faces of the type "TDO" is accurately measured at the factory during final assembly and the cone spacer is ground and fitted to give a predetermined amount of bench lateral looseness in the two rows of rollers. The importance of proper fitting practice in the use of a bearing of this type cannot be over emphasized.

When bearing races are applied with interference fits required by the installation the cones will expand or the cups will contract, depending of course upon which race is press fitted. This will tend to reduce the radial clearances in the bearing. This special spacer fitting not only takes into consideration the reduction in clearances due to the interference fits but also the looseness necessary to compensate for any temperature differentials of the bearing races from the various sources previously covered.

Failure to follow the proper fits will cause a change in bearing lateral with the result that bearings may not perform as well or give as long trouble-free service as would be the case if the bearings are properly fitted to the shaft.

Coupling maintenance—Anti-friction bearings are designed into mill applications to withstand the radial loads and thrust loads that are commonly prevalent.

Figure 33 — Magnetic plugs are very effective in detecting steel and iron particles in the lubricant.



Due to the wear of various auxiliary parts of the mill, heavy thrust loads which are considerably beyond those for which the bearings were intended, have been found to exist. Wear in couplings driving mill stands has been one of the critical causes of bearing failures in several installations. In one installation of a rod mill, the original bearings furnished with the mill operated for a period of many years before some difficulty was experienced from reduced bearing life and roll neck breakages. After a considerable amount of investigation by the mill operating men, as well as our service engineers, it was found that the wear and clearances in the couplings caused such a terrific pounding action that roll necks were actually broken from static and fatigue stresses. In addition to roll neck breakages there was also a serious effect on the bearing life which was being obtained. End thrusts are also developed from badly worn couplings or wabblers. This can be especially true since many of these mills are operating at much higher speeds than was common practice years ago. The use of universal couplings has been a decided step in improving this condition.

Magnetic plugs—Figure 33 shows arrangements of magnetic plugs for detecting steel or iron particles in oil or grease. These particular plugs are especially useful in inspecting the lubricant in gear housings since the adapter in the operating position will collect any metal particles on the magnetic plug. An inspection of the plug shows how the outer adapter can be partially removed from the housing without losing the oil in the gear case after which the inspection plug can be withdrawn to determine whether any metal particles have been collecting on the magnet. This plug was recently designed by one of our service engineers and can be readily used in connection with not only gear drives but roll neck bearings as well.

Storage precautions—Wherever possible, bearings should not be removed from boxes in which they were packed by the bearing manufacturer until such time as there is a reasonable decision as to how soon this bearing is to be used. After the bearings are built by the manufacturer, the bearing is prepared for shipment by inserting oiled cardboard slips between the rollers and cup surfaces. The complete assembly is also submerged as a unit in a tank filled with hot petrolatum to thoroughly cover all the rolling elements of the parts of the bearing and also other parts which might be otherwise subjected to corrosive action. The bearing is then wrapped in oiled paper and packed in a specially built wooden box of such a design that none of the bearing parts contact the wood portion of the box. It is conceivable that there may be times when green lumber could be used and that the moisture from the lumber might seriously corrode the bearing surfaces. With this precaution by the manufacturer it also holds that the same type of precaution should be taken by the user until such time that the bearing is placed in service. The bearing should always be kept in protected areas to be reasonably certain that dirt, moisture, or other contaminating mediums will not come in contact with the parts.

Recent experiences in the reclamation of defense material used in World War II is quite indicative that the precautionary measures that were employed in storing the machine tools, etc., for possible later use were not entirely adequate. Unfortunately, when the so-called "moth ball" packing procedure was used, the problems of condensation were in some cases overlooked entirely.

Great care was taken to thoroughly seal the equipment by means of plastics, etc., but in a great many cases it has been found in the last 5 or 6 months that the moisture trapped within the bearing unit and the condensation involved has severely damaged not only the anti-friction bearings in the equipment, but also the highly polished and ground machine surfaces such as shafts and gears as well.

Where the normal evaporation is not permitted in the case of steel mill drives, the same condensation will occur within the gear case and will certainly contaminate the lubricant unless the oil is changed at regular intervals in oil level systems, or if a full circulating oil system is used and unless proper precautions are taken to properly separate the condensation from the lubricant. This can quite readily be accomplished by the use of proper centrifuge systems which are available on the market today.

Foreign particles that may have entered the system should also be removed with proper filtering equipment.

Lubricant in oil splash gear cases should be changed frequently to avoid corrosive action on the bearing parts from moisture. Such a maintenance program is a very good investment since the cost of a few gallons or pounds of lubricant is a very small percentage of the possible costs of the effects of corrosion not only on the bearing parts but also the gearing as well.

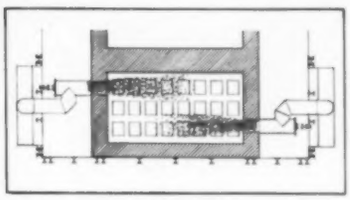
Closures—The selection of a proper closure design for a specific application is usually the responsibility of the manufacturer of the equipment. However, quite frequently it is necessary to make changes in the design of closure to meet certain specific operating problems or operating conditions. A closure design should be selected after reviewing the consistency of the lubricant, the foreign material to be excluded, the speed of the application, and the conditions surrounding the machine such as dust, mill scale, or other materials which might cause a lapping agent. Likewise, water, acid or inferior lubricant will etch not only bearing parts but gear surfaces as well.

Bearing life—With proper care and maintenance, roller bearings used on mill rolls and auxiliary equipment should give long and satisfactory life. They should have been selected as being adequate to give good tonnage or hours of life depending upon the type of equipment in which they are applied. They should, of course, be mounted correctly, well enclosed and properly lubricated at regular intervals.

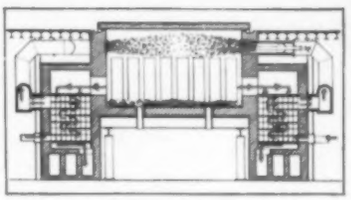
With the advent of higher and higher mill speeds, various types of warning signals and recording devices which register loads and temperatures help to guard against abnormal conditions. Regular inspection and lubrication schedules are of paramount importance to assure the maximum return of every dollar invested in such production machinery.

RUST
Continuous Fired
SOAKING PITS

- Two-way Fired
- Recuperative Type
- Fully Automatic
- Choice of Fuels



PLAN VIEW



CROSS SECTION

Thanks to superior design, Rust Soaking Pits have greater charging capacity per square foot of area. Sketches above indicate the diagonal two-way firing, by which heat is distributed uniformly throughout the pit; on cut backs both ends of pit remain in balance, thus ingots soak out evenly. absence of impingement increases life of refractory walls and covers.

Design permits construction in batteries of two or more holes. With 45 years of experience as a background, Rust engineering from start to finish guarantees the utmost in efficiency and economy.

For Either a New or Modernization Job, Consult Rust Now!

THE WHOLE JOB IS ONE JOB WITH A

RUST "PACKAGE" CONTRACT

ONE RUST CONTRACT covers everything . . . from blueprint to test-run. Rust assumes responsibility for design, manufacture and erection of all essential material . . . including excavations, foundations, wiring and piping. Your purchasing and engineering departments are freed of subcontractor headaches when you order from Rust.

F-3

RUST FURNACE CO.

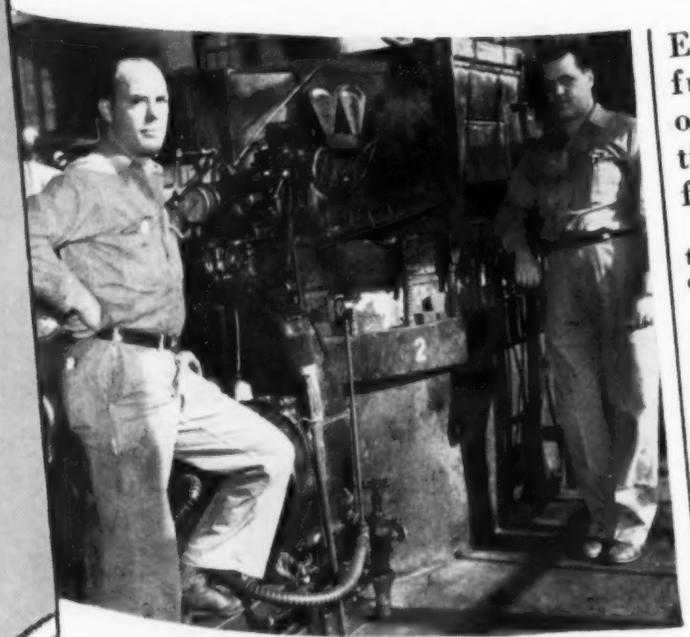
PIONEERS IN FURNACE DESIGN

PITTSBURGH, PENNSYLVANIA

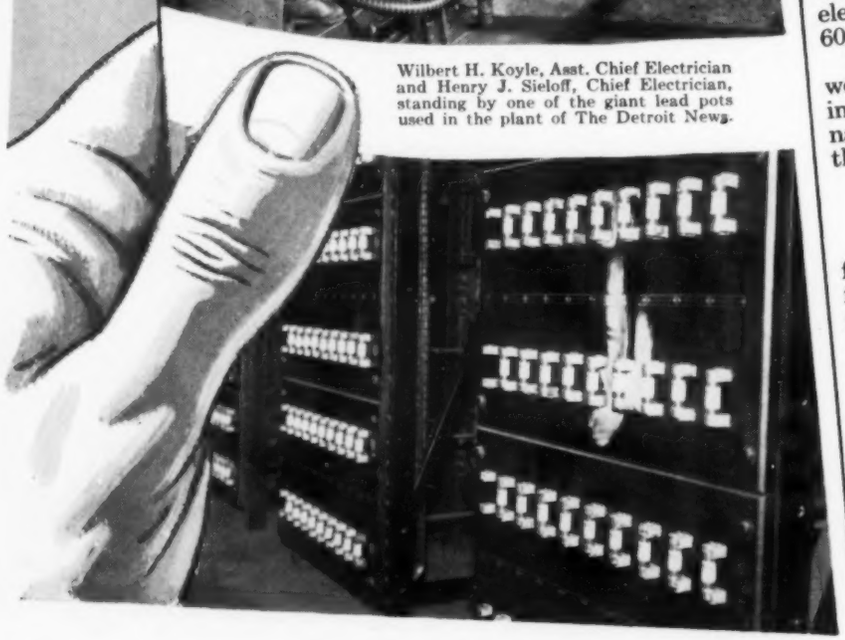
Phone Atlantic 1-8870

The Detroit News
WSPAPER FOR MORE THAN 77 YEARS
es Weekday and Sunday, of Any Michigan Newspaper

FUSE FAILURES ON LEAD POT CIRCUITS STOPPED COLD — BY CHANGING TO FUSETRON FUSES



Wilbert H. Koyle, Asst. Chief Electrician and Henry J. Sieloff, Chief Electrician, standing by one of the giant lead pots used in the plant of The Detroit News.



Excessive heating of ordinary fuses caused 3 to 4 fuses to open every week. Cooler operation of Fusetron dual-element fuses cured trouble completely

"Prior to May 20, 1950, we had a bad time keeping all the electric heating circuits on our lead pots in full operation.

"We have two eight-ton lead pots and one six-ton. Each is electrically heated by single phase, 220 volt, 10 kilowatt elements, fed from a 220 volt, 3 phase source. The circuits on each are protected by sixty 60 ampere and nine 400 ampere, 250 volt fuses.

FOUND 6 TO 8 FUSES BLOWN

"To be sure that all heating elements were operating properly, we used to check all 207 fuses about once in two weeks. Generally our maintenance electrician would find six to eight of the 60 ampere fuses open.

"This meant that our melting pots were not operating at full efficiency and in addition to this loss, our fuse maintenance and purchases were greater than they should be.

WITH FUSETRON FUSES NOT ONE OUTAGE

"As an experiment, we changed all fuses over to FUSETRON dual-element fuses of the same amperages as had been previously used.

"To date, March 9, 1951, or after about nine months of using Fusetron fuses, our records show that not one of them has failed.

"We attribute this remarkable result to the lower resistance of Fusetron fuses which allows them to operate at a cooler temperature than other fuses that we have used."

Henry Sieloff. Chief Electrician
The Detroit News, Detroit, Mich.

Fuses that Protect in 10 Ways now Available

Fusetron dual-element fuses offer user surprising advantages

1 ★Protect against short circuits.

2 Protect against needless blows caused by harmless overloads.

3 Protect against needless blows caused by excessive heating — lesser resistance results in much cooler operation.

4 Provide thermal protection — for panels and switches against damage from heating due to poor contact.

5 Protect motors against burnout from overloading.

6 Protect motors against burnout due to single phasing.

7 Give DOUBLE burnout protection to large motors — without extra cost.

8 Make protection of small motors simple and inexspensive.

9 Protect against waste of space and money — permit use of proper size switches and panels.

10 Protect coils, transformers and solenoids against burnout.

★Fusetron Fuses have high interrupting capacity as shown by tests of the Electrical Testing Laboratories of New York City in December 1947.

Details on the Fusetron dual-element Fuse

A fuse link combined with a thermal cut-out — the result, a fuse with tremendous time-lag and much less electrical resistance.

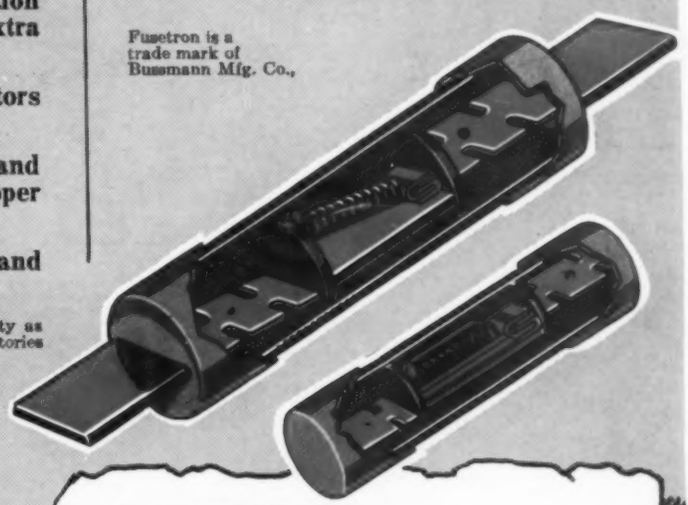
They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

Made to same dimensions as ordinary fuses, FUSETRON Fuses fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprisingly low.

Fusetron is a trade mark of Bussmann Mfg. Co.,



Don't risk losses in your plant!

One **needless** shut-down,
One **lost** motor,
One **destroyed** panel or switch,
One **burned out** solenoid . . .
May cost you more than replacing every ordinary fuse with a FUSETRON dual-element fuse.

Bussmann Mfg. Co.,
University at Jefferson, St. Louis 7, Mo.
(Division of McGraw Electric Co.)

Please send me complete facts about FUSETRON dual-element Fuses.

Name.....

Title.....

Company.....

Address.....

City.....State.....951

PORTABLE BREATHING UNIT AIDS FURNACE REPAIRS

▲ For all their rugged construction, blast furnaces in steel mills require a lot of attention. One of the essential jobs — one that consumes considerable time — is replacing piping and flushing the furnace coolers to clean them. It means that men must work in high temperatures and concentrations of toxic fumes. There is no other way. The length of time men can work safely on this job during one shift is limited by the heat and fumes.

At the mills of the Weirton Steel Co., Weirton, W. Va., a method now has been developed which enables cleaning crews to complete a furnace in about one-half the time previously required, without danger from toxic fumes no matter how heavy the concentrations. This method which has proved itself to be satisfactory over more than a year and a half of use, calls for equipping the workmen with self-contained, oxygen-generating breathing apparatus. The savings in man-hours for this operation have more than compensated for the initial cost of the apparatus. At the same time, Weirton is living up to its Safety Creed as laid down by its president, Thomas E. Millsop:

> "Production is important but *safety* comes first with us. The Weirton Steel Co. is *not* interested in making money or records at the expense of human life or suffering."

Working on the coolers at a height of some 25 or more feet above the outer floor around the blast furnaces, these cleaners at Weirton formerly wore an earlier type of breathing mask. On full eight-hour shifts, the men with this mask were able to work only two to three hours a day. The balance of the time was spent in climbing to, or down from their working posts; in shifting positions when the furnace was "bled" or was tapped, and in making sure that their masks were in working condition. At times, fumes rose in such heavy concentrations that the masks could not cope with them and the men had to leave their working posts and move to safer locations.

Figure 2 — These two men are descending an 85-ft deep manhole to repair a "blow" in a 10-in. gas main running under the Ohio River between Weirton's mills at Weirton, West Virginia, and Steubenville, Ohio. Their self-contained chemox breathing apparatus is equipped with speaking diaphragms that enable conversation in gaseous concentrations without removing the masks.

Figure 1 — Wearing self-generating oxygen breathing apparatus, two workmen are shown cleaning one of the coolers on a blast furnace shell. Both men wear laminated plastic safety hats, to protect them from injury due to falling objects, heavy protective clothing and the chemox breathing apparatus.

Since the men have been equipped with chemox oxygen generating units, according to Milo Gray, Weirton's Safety Manager, they remain on the job for almost a full shift. "They only have to move when a tap is made and to replace the canisters of chemical that supply them with oxygen," he said. "They work in comfort no matter how heavy the concentration of fumes may be."

Chemox is a light-weight (13½-lb in all), easily donned and adjusted, apparatus which makes its own oxygen as the wearer breathes. Developed by Mine Safety Appliances

Heppenstall KNIVES

...give you an "EDGE" on competition!

In metal cutting, shearing, or trimming operations you can keep costs 'way down . . . and production up . . . by standardizing on Heppenstall Knives!

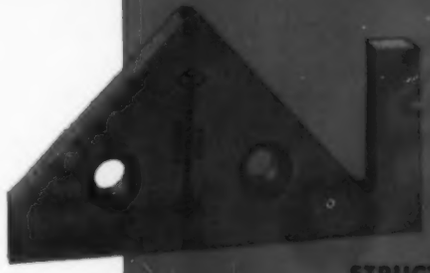
If you're not using them, don't be satisfied with the "average service" you think you're getting with your present knives. Specify Heppenstall Knives . . . and honestly, you'll be surprised at the difference!

Long-time users know that Heppenstall Knives, made from our own electric induction steels, are the finest knives obtainable. They consistently deliver greater tonnage per edge . . . more and cleaner cuts per grind . . . per knife . . . and per dollar of original cost. Why not order a set today?

Heppenstall Company, Pittsburgh 1, Pa.
Sales Offices in Principal Cities.

Heppenstall

-The most dependable name in forgings...



Co., Pittsburgh, Pa., just prior to the entry of the United States into World War II, it was used by the Navy under severe fire and battle conditions throughout the war, and today it is standard equipment in the peacetime Navy. It is approved by the U. S. Bureau of Mines.

Operating independently of outside air, the apparatus employs a replaceable canister containing a chemical which, upon contact with the moisture in the exhaled breath, evolves a plentiful supply of oxygen for breathing requirements. It is equipped with an automatic timing device which rings a bell at the end of a pre-set time interval. This indicates that the wearer should return to fresh air, and replace the canister. A minimum of 45 minutes of pure, moisture-free oxygen is assured and the wearer is provided with complete respiratory protection in oxygen-deficient and highly gaseous atmospheres. The lenses of the full-vision facepiece are kept free from fog by the flow of fresh oxygen giving workers unobstructed vision.

"We use about eight chemox units among the shell-cleaning crews at the blast furnaces," Mr. Gray said. "We have found that they have saved us more than their cost on this one job alone as well as permitting the workmen to perform their duties in comfort and safety."

Weirton employs the chemox apparatus for other jobs at its mills. Wherever it is necessary to work in oxygen deficient atmospheres, or when gas masks are not suitable, workers, inspectors and others are equipped with the oxygen-generating apparatus.

Repairs had to be made recently to a big valve on a 10-in. gas line which runs between mills at Weirton and Steubenville, Ohio, some six miles away. Near a spot where this line dips to cross under the Ohio River, a valve "blew."

A month or two later while further repairs were being made to this gas line, work which involved the "pulling" of a valve, there was another blow-out. This happened while a chemox-equipped workman was some 85 ft down in a 10 ft diam man-hole. The man scrambled to the surface by means of a ladder which is equipped with hoops to prevent persons using it from falling.

"Although stunned momentarily by the force of the escaping gas," Mr. Gray said, "the man managed to climb the ladder. When he got to the surface and fresh air in a safe area he removed his breathing apparatus. He told me: 'If I hadn't had that mask, I never would have made it.' "

Mr. Gray said that if the man had been knocked unconscious he would have been raised to the surface by means of a life line which was attached to the sturdy harness of the chemox unit which also serves as a safety belt.

Plan to attend!

Annual Convention

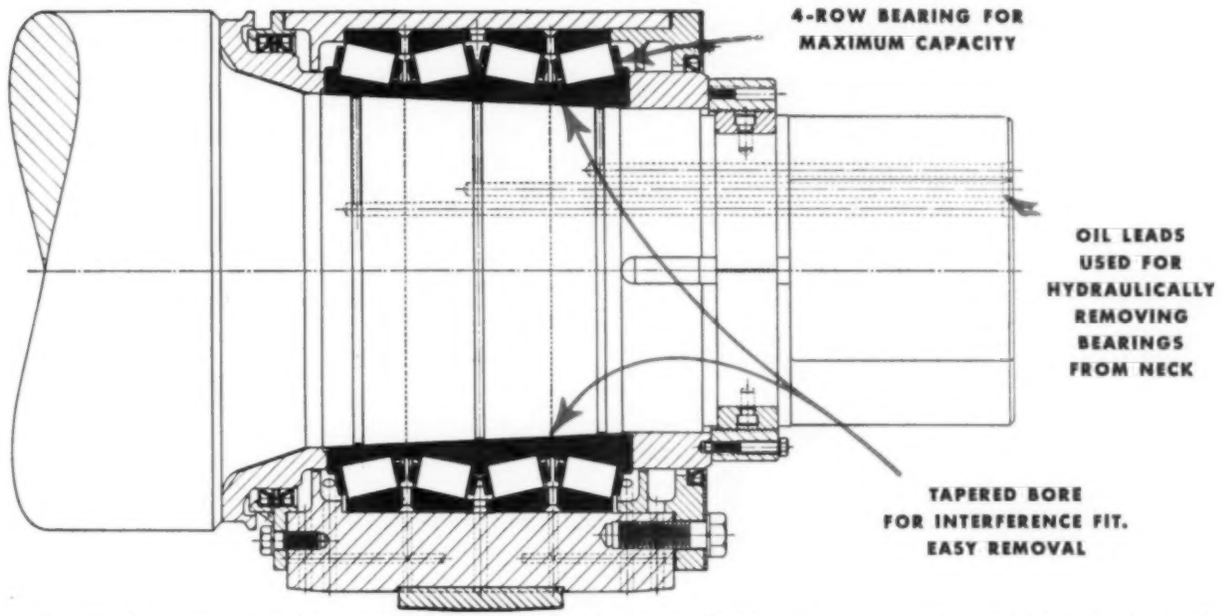
Association of Iron and Steel Engineers

October 1, 2, 3 and 4, 1951

Hotel Sherman

Chicago, Illinois

New 4-row TIMKEN® bearing has tapered bore...combines interference fit with easy removal!


4-ROW BEARING FOR MAXIMUM CAPACITY
OIL LEADS USED FOR HYDRAULICALLY REMOVING BEARINGS FROM NECK
TAPERED BORE FOR INTERFERENCE FIT. EASY REMOVAL

New Timken 4-row tapered bore roll neck bearings are already specified for use in a new 31" x 56" 2-hi temper pass mill, to be built by United Engineering & Foundry Company. Bearing application for this new mill is shown above.

AGAIN the Timken Company has pioneered roll neck bearing design. For the first time, high-speed mills requiring maximum bearing capacity with easy bearing removal can have a 4-row tapered roller bearing with an interference fit between bearing and roll neck.

It's made possible by a tapered bore, long used in 2-row bearings and now developed and introduced by the Timken Company in this new 4-row roll neck bearing. The new Timken® 4-row tapered bore roll neck bearing is the greatest development in roll neck bearings since the Timken Company pioneered the first balanced proportion bearing in 1941.

Like other Timken roll neck bearings this new tapered roller bearing permits maximum roll neck size and greater mill rigidity, eliminates need for special thrust bearings, gives greater tonnage life expectancy, makes possible higher rolling mill speeds, permits stopping and starting of mills without loss of steel.

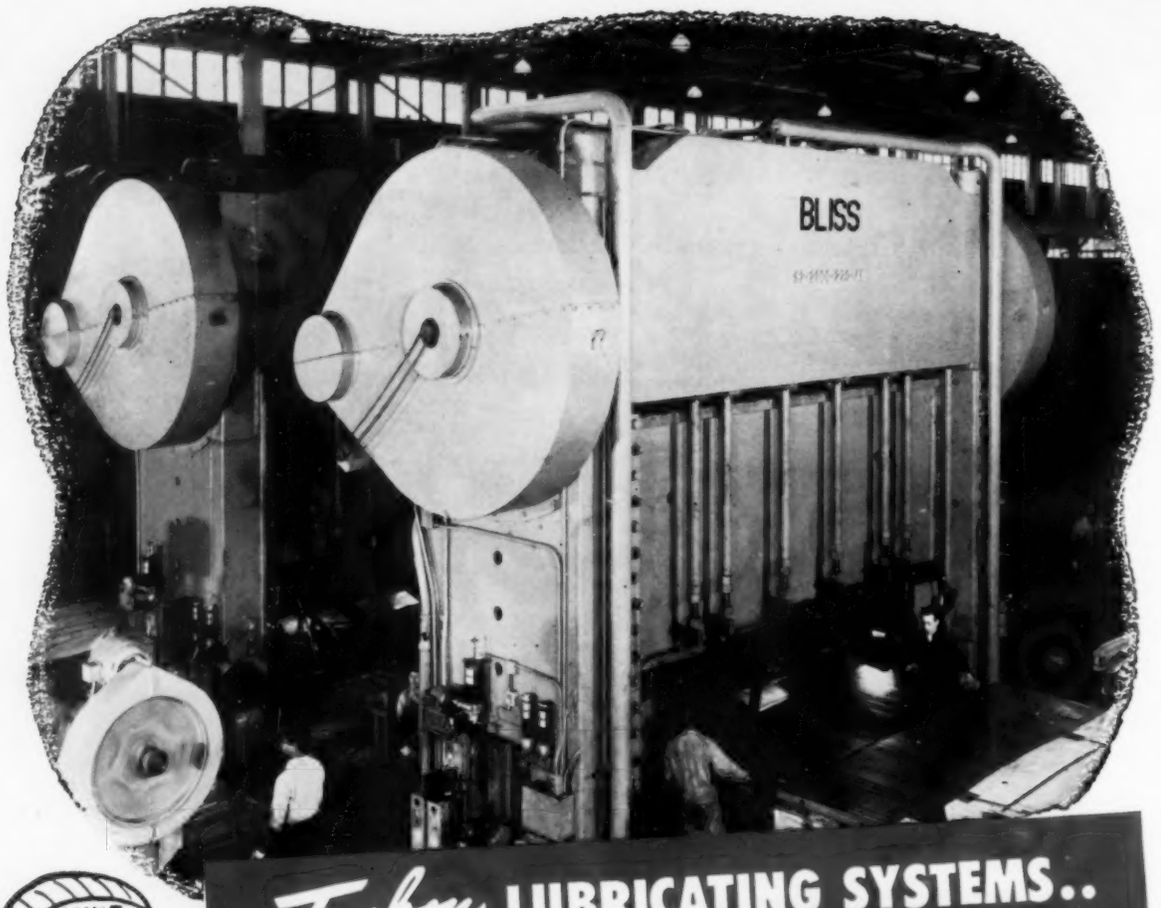
For additional information on the new 4-row tapered bore roll neck bearing, write The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◎ AND THRUST →◎← LOADS OR ANY COMBINATION ✳



Trabon LUBRICATING SYSTEMS..

- PREVENT COSTLY DOWN TIME—
- PROTECT BEARINGS—
- ASSURE MORE PRODUCTIVE HOURS!

You can keep your machines rolling day after day and year after year, with trouble-free Trabon Lubricating Systems. Trabon is positive, accurate, makes certain that every connected bearing receives the desired amount of lubricant *while the machine is running.*

On steel mill equipment, overhead traveling cranes, forging machines, crushers, presses, shears, and other machinery of all kinds, Trabon Systems have, for 21 years, been prolonging bearing life, eliminating rejects, cutting down time, and increasing production records.

Specify and install Trabon. The record shows—There are more Trabon Automatic Lubricating Systems in operation than all other makes!

Trabon

OIL AND GREASE SYSTEMS

TRABON ENGINEERING CORPORATION
1814 East 40th Street • Cleveland 3, Ohio

Date-line Diary...

August 2

▲ The RFC cut price of grade A tin 3¢ to $1.03 a lb.

▲ Pittsburgh Consolidation Coke Co. has put into operation a new push button coal cleaning and sizing plant, which can produce 1275 tons of coal and iron at Cadiz, Ohio.

August 3

▲ NPA told tin can manufacturers that they would get 1,000,000 tons of steel each quarter for the year beginning October 1. Industry spokesmen feel this is insufficient.

August 4

▲ NPA acted to give machine tool builders a super priority.

▲ New construction was banned by NPA except where a minimum of steel, copper and aluminum is used.

▲ Auto and truck production for this week fell to 114,519 units compared with 173,169 units a year ago according to Ward's Automotive Reports.

August 6

▲ The Petroleum Administration for Defense stated that it had authorized purchases of 300,000 tons of casing and tubing to oil and gas operators for the fourth quarter.

▲ According to the AISI, the operating rate for the steel industry for the week beginning August 6 is scheduled at 101.1 per cent of capacity. This is equivalent to 2,021,000 tons compared with 2,029,000 tons one week ago.

August 7

▲ NPA stated that slab zinc allocations for 70,000 tons were made in August. Requests were about double this figure.

▲ Westinghouse Electric Corp. obtained contract from Great Lakes Steel Corp. for the electrical equipment for 72-in. slabbing mill. Mill will be in production by the end of 1952.

▲ American Railway Car Institute reports July production of freight cars totaled 5290, orders were 2417, leaving a backlog on August 1 of 144,810. Strikes affected July production.

August 8

▲ Bethlehem Steel Corp. borrowed $100,000,000 on notes arranged through Guaranty Trust Co. of New York. Money is needed for construction program.

▲ Common stockholders of Thomas Steel approved plan to merge with Pittsburgh Steel. Thomas Steel will be dissolved and assets and property will be transferred to Pittsburgh Steel.

August 9

▲ The ICC granted freight increases of 6 to 9 per cent. Eastern carriers received 9 per cent, southern and western carriers received 6 per cent. Boosts include temporary rate increases given last March. New rates will add $548,000,000 annually to rail revenues.

▲ Agriculture Department predicted a cotton crop in 1951 of 17,266,000. This will be 7,254,000 above last year.

▲ Steel producers launched a nation-wide campaign to increase flow of iron and steel scrap to the mills.

▲ Census Bureau reported that government taxes, federal, state and local were a record of $54,626,000,000 in the calendar year of 1950.

August 10

▲ Bureau of Mines reports during March 1951, steelmaking furnaces used 4,525,037 gross tons of scrap and 4,609,594 gross tons pig iron.

▲ AISI reports shipments of steel products in June totaled 6,645,900 net tons, a record for any 30 day month. For the first half of 1951, 40,006,000 net tons were shipped. This is 15 per cent higher than the first half of 1950.

▲ Freight traffic on U. S. railroads dropped last week below 1950 levels for the fourth successive week, declining to 813,366 cars.

▲ British Steel Production fell to an annual rate of 13,317,000 in July. Production for 1951 is now estimated at 16,000,000 tons compared with 16,300,000 tons for the previous year.

▲ Stockholders of Pittsburgh Steel Co. voted to increase the company's authorized stock, which will be used for the acquisition of Thomas Steel Co.

August 11

▲ Agriculture Department reports that the wheat crop this year will be 998,000,000 bu, thus dropping below 1,000,000,000 for the first time since 1943.

▲ Commerce Department reported that personal income in June climbed to a record annual rate of $251,000,000,000.

August 13

▲ Based on reports of companies having 93 per cent of capacity of the steel industry, the operating rate for the week beginning August 13 is scheduled at 101.5 per cent of capacity. This is equivalent to 2,029,000 tons compared with 2,021,000 tons one week ago.

▲ According to the FTC profit rates after taxes for twenty-two major industries was substantially higher in 1950 than 1940.

August 14

▲ Federal Reserve index of industrial output announced industrial production in July fell to the lowest level since last November. The President's Council of Economic Advisers reported corporation profits before and after taxes also slid during the second quarter.

▲ Weirton Steel Co. tapped the first heat of steel from their second 550-ton open hearth furnace.

▲ The F. W. Dodge Corp. reports that construction contracts in the 37 states east of the Rockies, for the first seven months of 1951 set a new high of $10,187,939,000 or 23 per cent greater than the same period in 1950. Construction awards in July dropped 2 per cent from the previous month to a figure of $1,379,830,000.

August 15

▲ Defense Mobilizer Wilson estimates that the new price control provisions of the new Defense Production Act will increase living cost 5 to 8 per cent.

▲ United Engineering and Foundry Co. reports net income for the first six months of 1951 of $1,933,944 or $2.33 per common share after preferred dividends compared with $4.14 a share for the same period of 1950. Net sales totaled $29,363,816 compared with

$36,489,448 for the same period one year ago.

August 16

▲ OPS estimates that increased freight rates will increase retail price very appreciably during the next year.

▲ Pennsylvania Railroad plans to build a new $8,000,000 iron ore pier on the Delaware River at Philadelphia, which will have a rated capacity of 2400 tons per hr.

▲ British iron and steel prices were increased with some increases running up to 25 per cent.[1]

August 17

▲ Production of primary aluminum for the first half of 1951 exceeded 1950 by 18 per cent and reached the highest level since 1944. Total production in the first half was 807,181,724 lb. Production in June totaled 134,906,971 lb.

August 18

▲ United States Steel Corp. purchased three 61-oven batteries from the Koppers Co. to be built at the Clairton, Pa. works.

▲ Defense Mobilizer Wilson said that some scarce materials are being released from government stockpiles for defense production needs.

▲ Economic Stabilizer Johnston approved the wage stabilization formula which will allow wages to rise as much as the cost of living increases.

▲ Steel producers will be authorized by the NPA to accept or reject orders under CMP regardless of date of receipt until fifteen days before the first day of the month in which delivery is requested.

August 20

▲ Commerce Department reports that output of goods and service in the second quarter reached a record high annual dollar rate of $326,000,000,000.

▲ The Labor Department announced that average work week in manufacturing plants in July dropped to 40.4 hrs compared with 40.8 hrs in June.

▲ Great Lakes Steel Corp. was awarded special tax benefits of $24,751,120 for the construction of the 72-in. slabbing mill in their construction program.

▲ According to AISI, the operating rate for the steel industry for the week beginning August 20 is scheduled at 100.4 per cent of capacity. This is equivalent to 2,007,000 tons compared with 2,029,000 tons one week ago.

August 21

▲ NPA cut back structural steel allotments and this will slow down the steel industry expansion program. Plants such as the Fairless Works will probably have delayed completion dates.

▲ Machine tool manufacturers were given an additional 10 per cent price boost by OPS.

August 22

▲ Dominion Iron and Steel Corp. of Sydney, Nova Scotia awarded Koppers Co. contract for 61-new by-product coke ovens which can carbonize 1400 tons of coal a day.

▲ Republic Steel Corp. plans to convert a 70-ton side door electric furnace at South Chicago to top charge thus increasing its electric furnace steel production by 50,000 tons a year.

August 23

▲ National Steel Corp. declared a dividend of 75¢ a share for the third quarter of 1951.

▲ Railroads plan to put the newly authorized freight rates into effect on August 28.

▲ A bill which would appropriate $20,000,000 for 40-ft channel in the Delaware from Philadelphia to Trenton was killed.

▲ Bethlehem Steel started preliminary work on an iron ore deposit at Marmora, Ontario. Planned production is 400,000 tons annually.

▲ Allegheny-Ludlum declared a 50¢ per share dividend payable September 29, thus raising dividend totals to $1.50 for 1951.

August 24

▲ NPA announced that the steel allocation for tin can manufacturers of 4,000,000 to 4,400,000 tons for the year beginning October 1 will produce a record tonnage of cans.

▲ U. S. Steel awarded Gibbs & Hill, Inc. a contract for a 60,000-kw electric power station at Morrisville, Pa.

August 25

▲ Rise in cost of living in month prior to July 15 provided automatic pay boost of 1¢ an hr at General Motors, Chrysler and Ford.

▲ S. W. Richardson has agreed to furnish the money required to carry out the Bureau of Mines manganese-from-slag project.

August 27

▲ Bethlehem Steel Co. has started a scrap recovery program in which it sends units to the scrap yards to process scrap for use.

▲ Great Britain allowed an increase in the price of scrap steel of $5.60 a ton over current average of $14.00 a ton.

▲ Based on reports from companies having 93 per cent capacity of the industry, the AISI reports that the operating rate for the week beginning August 27 is scheduled at 99.8 per cent of capacity. This is equivalent to 1,995,000 tons compared with 2,007,000 tons one week ago.

▲ Copper industry has been practically paralyzed by the Mine & Smelter Workers walkout.

▲ RFC raised price of synthetic rubber 1½¢ to 26¢ a lb.

▲ AISC announced July bookings of fabricated structural steel of 223,795 tons and shipments of 202,408 tons. Backlog for the next four months totaled 1,134,-784 tons and total backlog is 2,687,974 tons.

August 28

▲ Lone Star Steel ordered a 45 x 80-in., 2-high slabbing and plate mill, and a 27 x 49 x 72-in., 4-high reversing hot strip mill.

August 29

▲ DPA official stated that scrap collection efforts must be intensified if the steel industry is to receive enough scrap to achieve its 1951 production goal of 110,000,000 tons of ingots and castings.

August 30

▲ Harrisburg Steel Corp. acquired the Boiardi Steel Corp. of Milton, Pa. Boiardi has an annual capacity of 50,000 tons of steel bars, angles and shapes, and Harrisburg Steel has an ingot capacity of 100,000 tons a year.

August 31

▲ The General Service Administration has been authorized to get scrap from Korean battlefields and India.

▲ Kennecott Copper settled their wage dispute granting a 15¢ hourly wage increase and a pension plan costing 4½¢ an hour.

▲ Treasury Department reports that government is spending at twice the rate of a year ago, and has gone over $3,000,000 in the red since July 1.

▲ CMP orders will be needed after October 1 for basic copper and copper alloy shapes.

▲ Government will buy over 200,000 tons of chrome ore and concentrates as this material is added to the government buying program.

Get McDOWELL

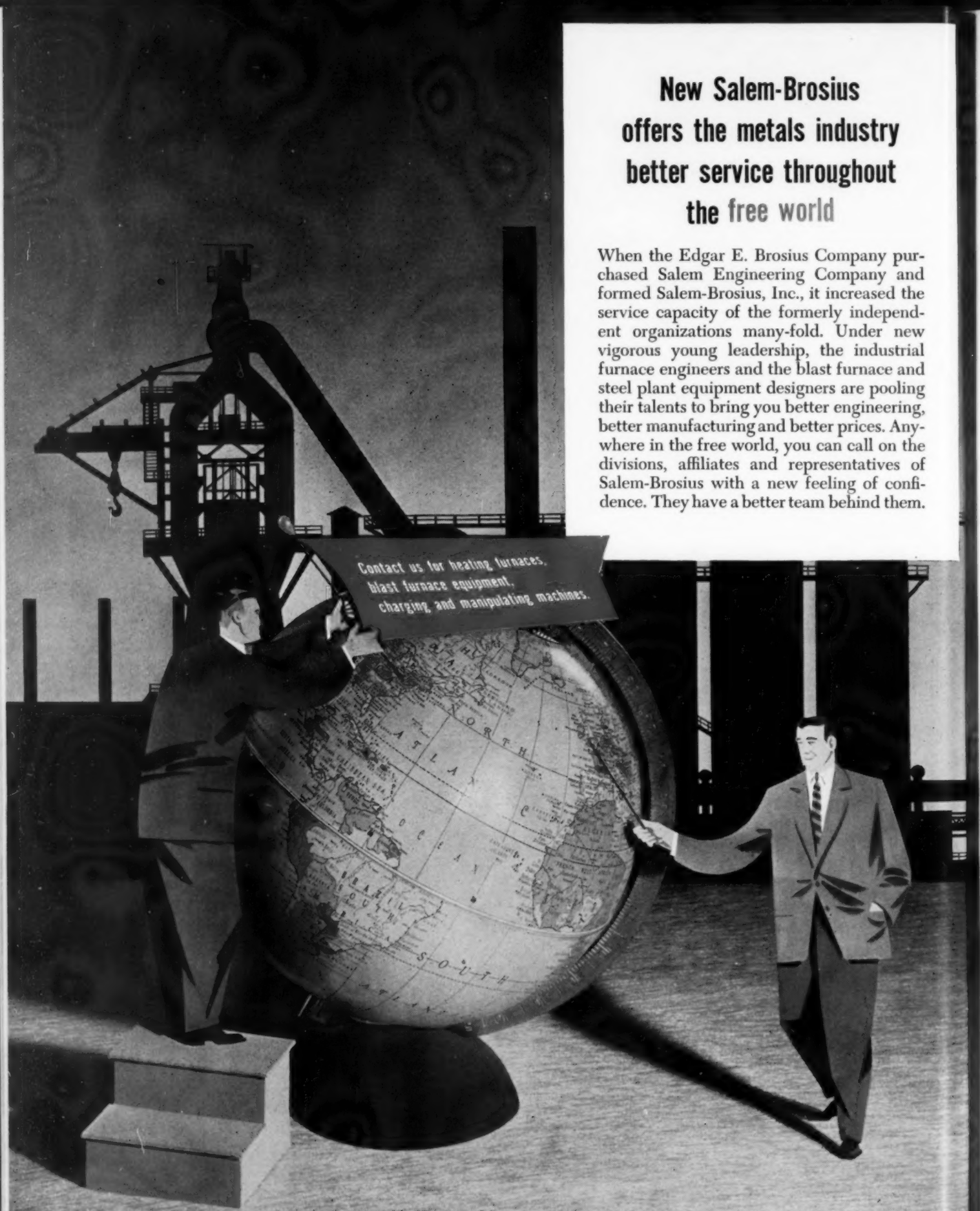
. . . . and get rid of your heavy erection problems. Get the McDowell Method and you get revved-up enthusiasm, a flair for the job – an understanding so intimate it will even assume turnkey responsibility. This Method continually builds sturdy friendships because those superior McDowell engineering and field forces are competently at home among *all* the varied facilities comprising a steel mill. To erect, install, dismantle, or alter – including complicated materials handling systems, complete process lines, and mill machinery – get the young aggressive outfit with the *can do* reputation; get the best, get *McDowell*.

Recently completed: Mechanical erection of 20,000 tons of Blooming, Bar, Billet and Seamless Mill machinery for National Tube Company at Lorain, Ohio.

McDOWELL COMPANY, Inc.

CONTRACTORS AND ENGINEERS

3203 West 71st Street • Cleveland 2, Ohio



New Salem-Brosius offers the metals industry better service throughout the free world

When the Edgar E. Brosius Company purchased Salem Engineering Company and formed Salem-Brosius, Inc., it increased the service capacity of the formerly independent organizations many-fold. Under new vigorous young leadership, the industrial furnace engineers and the blast furnace and steel plant equipment designers are pooling their talents to bring you better engineering, better manufacturing and better prices. Anywhere in the free world, you can call on the divisions, affiliates and representatives of Salem-Brosius with a new feeling of confidence. They have a better team behind them.

SALEM-BROSIUS, INC., Pittsburgh 15, Pa.

Affiliates: Brosius Division, Pittsburgh 15, Pa.; Salem Engineering Division, Salem, Ohio;
Salem Engineering Co., Ltd., Milford nr. Derby, England; Salem Engineering (Canada) Ltd., Toronto, Canada

Industry News...

FIRST "HEAT" IS TAPPED FROM WEIRTON'S NEW 550-TON OPEN HEARTH

▲ The first "heat" of steel was tapped August 14 from the new 550-ton open hearth furnace of the Weirton Steel Co., Weirton, W. Va. This giant furnace is approximately three times as large as the average size of open hearth furnaces used in the steel industry. The only other furnaces that equal it in size are several in the plants of Weirton Steel Co. and Great Lakes Steel Corp., Detroit, Mich., both are subsidiaries of National Steel Corp.

The furnace was placed in operation without ceremony. Five days of production time were saved by lighting the wood fire necessary to dry out the furnace hearth last week while finishing work on auxiliary facilities was still in progress.

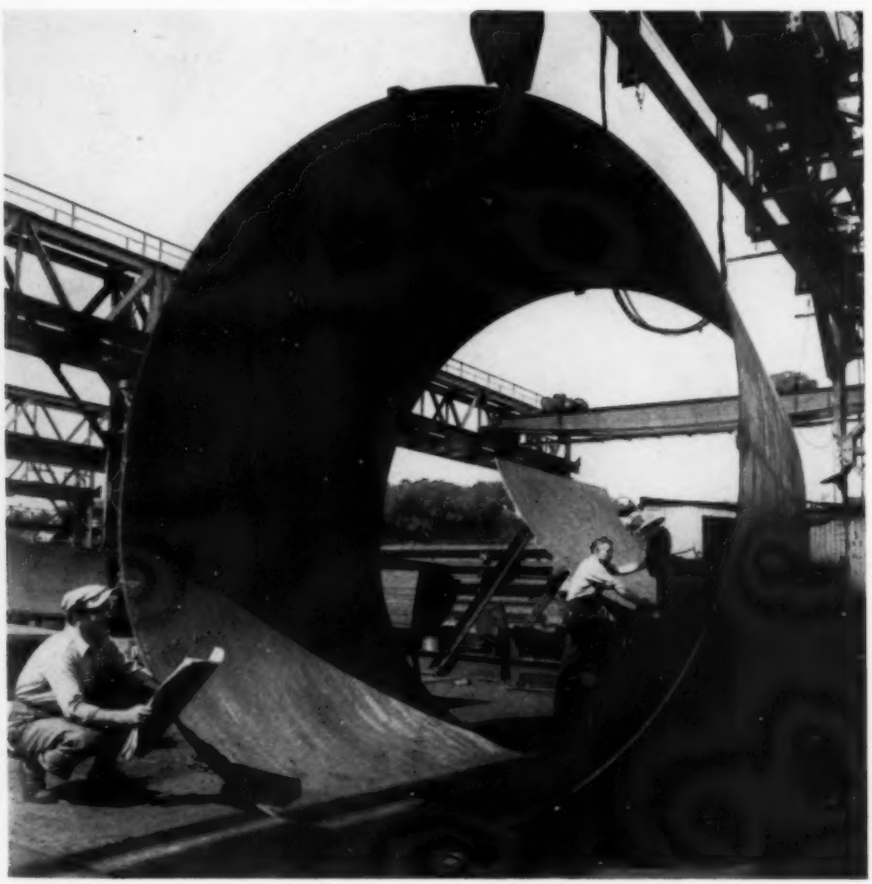
The new furnace is an important item in National Steel Corp.'s current expansion program which is being carried on at a cost of $150,000,000 to increase ingot capacity from the present total of 4,750,000 tons per year to 6,000,000 tons in 1953. Construction is underway on other major parts of the program, including a 480,000-ton per year blast furnace for which ground was broken at the Weirton plant several weeks ago and a blast furnace of the same size at the Great Lakes plant which will be completed in 1952.

To house the new Weirton open hearth furnace, it was necessary to build a 127-ft addition to the open hearth building. At the same time, the adjacent pouring aisle building was lengthened by 500 ft, and two new railroad trestles were constructed.

The new furnace was designed and built by the Weirton engineering and construction departments, the only outside contract being for the brick work. The furnace is equipped with seven charging doors and has two Isley controls. It is 96 ft, 6 in. long, 29 ft, 3 in. wide at the center, 24 ft, 6 in. wide at the ends, and 15 ft high from hearth floor to the top of the furnace. Approximately 1000 tons of steel and refractory materials equivalent to 1,000,000 9-in. bricks were used in construction of the furnace.

The new furnace brings the total number of furnaces in the Wierton open hearth shop to 13, all of which are considerably larger than the average-size furnace. The size of the furnaces requires auxiliary equipment that is proportionately large. The pouring aisle is equipped with four of the world's largest ladle cranes. The new furnace and the No. 1 furnace, which is of equal size, are each tapped into two 280-ton ladles, and the slag is run off into two 400 cu ft cinder pots.

FABRICATE STACKS FOR FAIRLESS OPEN HEARTHS



This 12-ft ring is the base for the first of nine towering open hearth stacks that will be erected at U. S. Steel's new Fairless works, under construction near Morrisville, Pa. The stacks are being fabricated in half-circle sections at the Ambridge, Pa. plant of American Bridge Co. The sections will be welded together at the plant site. This one piece alone weighs three tons.

ROLLING MILL CONTRACTS AWARDED BY U. S. STEEL

▲ Mesta Machine Co. announced the award of contracts for four major rolling mills for Fairless works of United States Steel Co., located at Morrisville, Pa. These units are in addition to the contract for an 80-in. hot strip mill previously announced.

The four new mills are: a 45-in. × 90-in. universal slabbing mill, a 48-in. five stand four high tandem cold reduction mill, an 80-in. four stand four high tandem cold reduction mill, and an 80-in. four high sheet temper mill.

The contract includes the engineering required for the arrangement of all the mechanical and electrical equipment for mills and services, ex-

cavation and piling diagrams, all reinforced concrete foundation drawings, piping drawings for all services of mill and motor room equipment, arrangement of control and operating stations, and field construction drawings for conduit and bus layouts.

The new 45-in. slabbing mill is designed to roll the largest ingots ever poured for the production of strip. The ingots will go to 40,000 lb with a maximum width of 78 in. The most powerful slabbing mill ever constructed, it will require 16,000 hp to drive it. To handle the tremendous tonnage which can be rolled on the mill two ingot buggies instead of one will be used for the first time on this type of mill.

The five stand 48-in. cold reduction mill will be the fastest of its kind in the world. On production of steel strip for tin plate speeds up to 7000 fpm are anticipated. This will mean that a continuous strip of steel three-quarters of a mile long can be rolled in thirty-five seconds.

The 80-in. four stand cold reduction mill will incorporate the latest in engineering design and its 21,550 hp makes it the most powerful mill of its kind. The 80-in. temper mill will be powered to operate at a speed higher than has been attempted previously for sheet products.

Work is in progress on all of these mills. The first to be delivered will be the 48-in. five stand cold reduction mill which is scheduled for shipment late this fall.

"CLEANER AIR WEEK" SCHEDULED FOR FALL

▲ "Cleaner Air Week" will be observed in the United States and Canada from October 21 to 27. This announcement was made by the Air Pollution and Smoke Prevention Association of America in conjunction with the United States Department of Commerce.

The observance was originally inaugurated to focus attention upon the need for control of air pollution from all sources, including smoke, soot, fly-ash, noxious fumes and gases, and to serve as a starting point for year-round smoke abatement and air pollution control activity by public officials, schools, industry, railroads, apartment houses, homes and civic institutions.

The week was formerly known as National Smoke Abatement Week,

Leaders OF INDUSTRY THE WORLD OVER

*AMERICA:
Allegheny Ludlum Steel Co.
American Steel & Wire Co.
Armco Steel Corporation
Bethlehem Steel Company
Carnegie-Illinois Steel Corp.
Cleveland Wire Works (G.E.)
Consolidated Vultee Airc. Corp.
Continental Steel Company
Copperweld Steel Company
Crown Cork & Seal Company
Empire Steel Corporation
Follansbee Steel Company
Jones & Laughlin Steel Corp.
Hofmann Industries
Mercer Tube Company
Mesta Machine Company
National Tube Company
Niles Rolling Mill
Parkersburg Steel Company
Reeves Steel & Mfg. Co.
Revere Copper & Brass, Inc.
Rochester Can Company
Sharon Steel Corporation
Superior Sheet Steel Co.
Tennessee Coal, Iron & R.R. Co.
Valley Manufacturing Company
Vilsack Fisher Mfg. Co.
Wheeling Steel Corporation
Wickwirc-Spencer (C.F.&I.)
Youngstown Sheet & Tube Co.

*CANADA:
Dominion Foundries & Steel Co.

*ABROAD:
A.R.B.E.D. Co., Luxembourg
Beautor Cie., France
DeWendell Cie., France
Formeaux Cie., France
Messrs. Thomas Baldwin, Wales
South African I. & S. Co., S.A.
Steel Co. of Wales, Wales
Swindon Iron Works, England
Yawata Iron & Steel Co., Japan

*(List is incomplete and growing)

RELY ON F·E·I· for...

OPEN HEARTH FURNACES,

SOAKING PITS, regenerative and one-way recuperative,

CONTINUOUS REHEATING FURNACES, Bloom, Billet and Slab,

DIRECT FIRED ANNEALING FURNACES for Sheet, Coil, Tool Steel Bars, Wire, other products

GALVANIZING FURNACES for Tubes, Sheets and Metalware,

SALT DESCALING FURNACES for Stainless Steel Sheet, Bar, other products

And Other Complete Heating Lines

In America and abroad, F.E.I. is recognized for top performance. You can rely on Furnace Engineers' skill, based on over 30 years' experience, to provide the most advanced heating methods. F.E.I.'s patented, automatically controlled combustion system provides high metallurgical quality and faster, more economical operation. Remember, F.E.I. is the complete buy . . . from plan to production.

Write for Bulletin . . . Tell Us Your Problem

6

Furnace Engineers, Inc.

F.E.I. Building • 1551 West Liberty Avenue • Pittsburgh 16, Pa.

SHENANGO Centrifugal CASTINGS ... KEY TO SAVINGS

Shenango offers a new way to

CUT DOWN ON ROLL REPLACEMENT

THOSE are exceptional run-out table rolls shown above.

First, they are Shenango *centrifugal* castings. Secondly, they're made of *Meehanite Metal.* Both are advantages in themselves. In combination they offer measurably stronger, pressure-dense metal, with finer, more evenly dispersed graphite, as well as freedom from blow holes, sand inclusions and other weakening defects.

The net result is a new high in resistance to wear and distortion.

Shenango is regularly producing centrifugally cast Meehanite Metal rolls of many types and sizes for mill service—finished or semi-machined to specification. So check with Shenango on rolls that cut down replacement because they *last* longer!

SHENANGO-PENN MOLD COMPANY
Centrifugal Castings Division
Dover, Ohio
Executive Offices: Pittsburgh, Pa.

SHENANGO

ALL RED BRONZES • MANGANESE BRONZES • ALUMINUM BRONZES
MONEL METAL • NI-RESIST • MEEHANITE® METAL

but its name was changed in order to cover the wider scope of activity of the association.

AETNA-STANDARD MOVES OFFICES TO PITTSBURGH

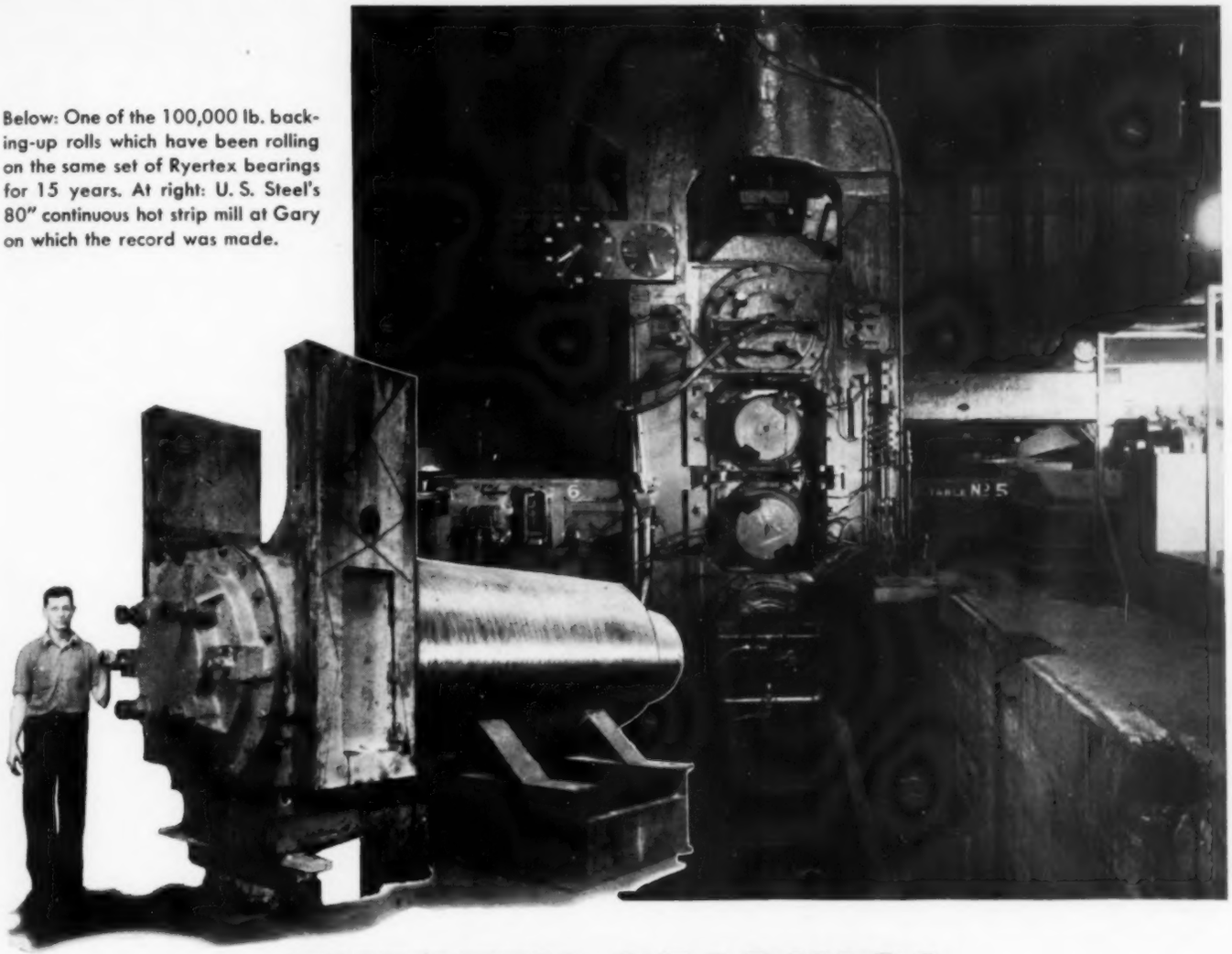
▲ Aetna-Standard Engineering Co. formerly, of Youngstown, Ohio, has recently moved its principal executive and sales offices to the Frick Building in Pittsburgh, Pa. Simultaneous with the move to Pittsburgh, the company's general offices were moved into a newly rebuilt four-story air conditioned office building in Ellwood City, Pa., where Aetna-Standard's principal plant is located. The company's management planned this move so as to provide a more closely united, more efficient organization where engineering, purchasing, accounting, and manufacturing will be centered in one location.

Along with these changes Aetna-Standard has also made strong moves toward a wider diversity of products. The company has for some time been working on extensive defense contracts and in the past year has entered both the rubber and plastic machinery and leather machinery fields.

Aetna recently became affiliated with Hale and Kullgren, Inc. of Akron, Ohio who are capably representing the company in the rubber and plastics industries. Hale and Kullgren, Inc. handle all engineering and sales for this class of equipment. Aetna's Warren, Ohio, plant is being used in the production of rubber mill machinery which means that with engineering for this machinery being done in Akron, the Warren plant will depend less and less on Ellwood City for its engineering. Thus the ideal of having a close relationship between the engineering and operating departments will be accomplished for both Aetna plants.

As a part of their expansion program Aetna-Standard has just constructed a new roll foundry on the company's property at Ellwood City. A new building for housing the foundry has been erected; the roll foundry office and new metallurgical laboratory are located in an adjacent building.

Equipment for both the foundry and laboratory are of the latest, most modern type available, all designed for high quality at high production rates. By careful planning it has been



Below: One of the 100,000 lb. backing-up rolls which have been rolling on the same set of Ryertex bearings for 15 years. At right: U. S. Steel's 80" continuous hot strip mill at Gary on which the record was made.

RYERTEX BEARINGS
in United States Steel Company's Mill

Ryertex Bearings on this broadside stand of the 80" continuous Hot Strip Mill at the Gary Sheet and Tin Mill of the United States Steel Company have been in continuous service since the mill started over 15 years ago. They have met all operating requirements satisfactorily. They are completely enclosed and operate with water as the only lubricant.

The necks of the backing-up rolls on which they fit are 36" in diameter. The barrel of the roll is 54" in diameter by 130" long and weighs about 100,000 lbs.

Ryertex Bearings are making remarkable records on all types of mill applications, from the heaviest to the lightest. Let us give you complete data covering increased tonnage, power saving, elimination of grease and oil, etc.

A typical group of Ryertex bearing liners. Ryertex can be molded to meet your specifications for bearings of any shape or size.

RYERSON - RYERTEX

JOSEPH T. RYERSON & SON, INC., RYERTEX DIVISION: NEW YORK • BOSTON • PHILADELPHIA • DETROIT • CINCINNATI
CLEVELAND • PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO

Straighten Pipe & Tube Up To 24" At High Speed

MEDART

MULTICYCLE STRAIGHTENERS

FOR PIPE & TUBE 1/16" TO 24" DIAMETER

THERE IS A DIFFERENCE IN STRAIGHTENERS! Only the Medart Multicycle offers a double straightening cycle, imposed by two bending stations to insure end-to-end straightness.

GENTLER HANDLING OF PIPE WALL! For large thin wall pipe or tubing the Multicycle employs dual-type bending rolls to distribute the straightening load around the tube circumference and eliminate usual single point high pressure concentration.

UNBALANCED TWISTING TORQUE ELIMINATED! Both top and bottom feed rolls are driven on the Medart Multicycle for balanced torque about the neutral axis of the workpiece.

SINGLE DRIVING MOTOR! Only one driving motor is required, insuring positively synchronized roll speed, longer roll life.

NO RUBBING GUIDES! All guiding action is accomplished by rollers mounted in anti-friction bearings — no friction or shoe-type guides are required.

COMPARE THE MULTICYCLE ADVANTAGES! Also straightens solid rounds — motorized setup adjustment on larger models — all gears running in oil — Timken bearing equipped throughout — many other patented features.

Write for Catalog

THE MEDART COMPANY 3535 DeKALB ST. ST. LOUIS 18, MO.

possible to begin production in the new foundry without shutting down the old foundry. The original foundry site is now being converted to machine shop floor space for mill machinery production.

The new foundry equipment will be capable of producing a wide range of roll sizes, from 7 in. to 36 in. in diameter. A large variety of types of rolls will also be available from the foundry, ranging from sheet mill and bar and billet mill rolls to small tube mill rolls.

FORD TO MODERNIZE RIVER ROUGE PLANT

▲ Ford Motor Co. will spend $43,000,000 to expand and modernize steel operations at River Rouge plant, adding 190,000 tons of annual finished steel capacity.

Planned are 37 coke ovens, a sinter plant, pig casting equipment and extensive improvements in the open-hearth and rolling mill facilities. A portion of the added coke capacity is earmarked for the new Ford foundry in Cleveland, Ohio. Alterations in the blooming mill will permit rolling of slabs up to 60 in. wide. Coil weights in the cold rolling mill will be increased up to an average 87 per cent.

RESEARCH CENTRALIZED AT PITTSBURGH COKE

▲ Pittsburgh Coke & Chemical Co. announced completion of the first major unit of its new central research laboratories at Neville Island near Pittsburgh, Pa. The new unit more than doubles the company's available laboratory space and centralizes a number of research groups previously located at a number of different points on Neville Island.

NATIONAL LEAD ACQUIRES REFRACTORY FIRM

▲ National Lead Co. has announced the acquisition of all the capital stock of the Charles Taylor Sons Co., manufacturers of special refractories. The Taylor company will be operated as a wholly-owned subsidiary of National Lead, under its present management, with main offices and a plant in Cincinnati, Ohio, and another plant at Taylor, Ky.

National Lead has been interested

Resists Corrosion!

Reduces Costs!

Wringer Roll fabricated from AMPCO* METAL

— just the thing for a continuous pickling line . . . less downtime, more production

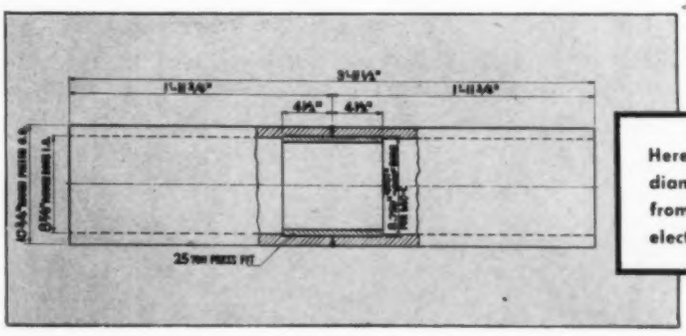
Yes, Ampco Metal resists corrosion as well as wear, pressure, impact and shock.

It's easy to fabricate, too, thanks to Ampco-Trode* Bronze Electrodes which have the same wear- and corrosion-resistant qualities as the parent metal.

And here's the payoff! Wringer rolls fabricated from corrosion-resistant Ampco Metal help you reduce replacement costs—cut downtime losses.

Ampco Metal is ideal for countless steel mill applications—wear plates, slippers, screw-down nuts, flash-welder dies, pickling equipment etc. Discuss your wear and corrosion problems with your nearby Ampco field engineer. He can show you where tough, wear- and corrosion-resistant Ampco Metal can keep production up and costs down.

Ampco Metal, Inc.
1745 South 38th Street, Milwaukee 46, Wis.
West Coast plant: Burbank, California



Here's a drawing of the wringer roll you see pictured above. Outside diameter of roll is 10¾", overall length 3'-11½". It was fabricated from 3 centrifugally cast sections of Ampco using Ampco-Trode 160 electrodes.

*Reg. U. S. Pat. Off., Ampco Metal, Inc., Milwaukee, Wis. a-7

Efficient Pickling with . . .

Rodine®

PICKLING ACID INHIBITORS

Use RODINE in sulfuric and muriatic acid baths for improved pickling and increased production.

In straight line pickling of wire, rod and tubing, RODINE makes available more metal for drawing by protecting steel from acid attack. In batch pickling of sheet steel, RODINE improves the surface. In rapid, continuous strip pickling, RODINE not only saves acid and metal, but also prevents over-pickling during line shutdowns.

Now, more than ever, it is cheaper to pickle with RODINE than without it.

"RODINE" meets Government Specification No. U.S.N. 51-I-2.

Write for descriptive folder on RODINE Pickling Acid Inhibitors.

AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PENNA.

for many years in the refractory field, as a producer and refiner of zircon. The parent company has a refractory plant at Niagara Falls, which is used to develop materials and methods for other refractory manufacturers.

Charles Taylor Sons Co. was founded in 1864 to manufacture fire-clay brick. In 1926, the company began production on sillimanite or mullite, bonded super refractories, and in 1933 added zircon refractories to the Taylor line. The manufacture of fire-clay products was discontinued in 1944, so that all facilities could be devoted to the exclusive production of these special high-temperature refractories. Mullite has as its chief component kyanite, which is imported mainly from India. An outstanding achievement of the company has been the development of artificial mullite, thus partially eliminating the uncertainties of overseas supplies.

Clifford R. Taylor is president and treasurer of the company. His grandfather, whose name the firm bears, was a fire-clay brick-maker from England, and the company has been in the family ever since. Other officers of the company who will continue to operate the firm are: M. C. Booze, vice president-secretary; R. W. Knauft, vice president in charge of sales; and Edwin L. Bohn, vice president in charge of production.

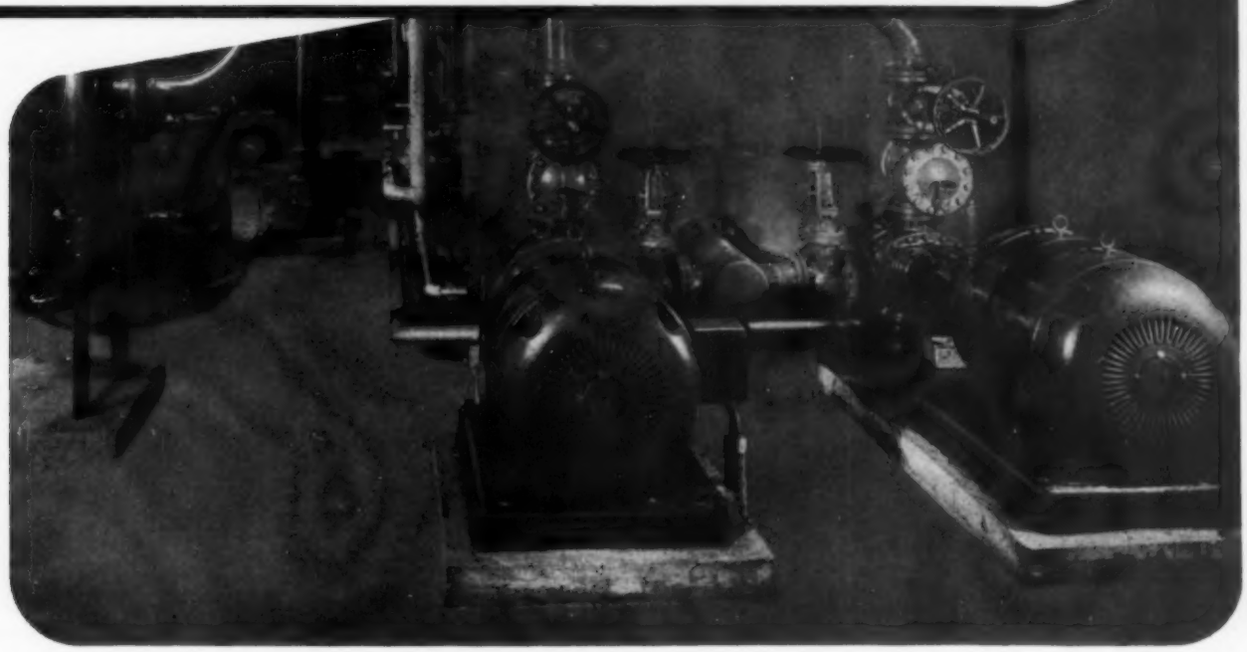
KILBY STEEL TO BUILD FURNACES FOR SHELLS

▲ Loftus Engineering Corp. has been awarded a contract by the Kilby Steel Co. of Anniston, Ala. for two heating furnaces and two heat treat lines for forging and treating 105 mm shells. All furnaces are gas fired, and have oil standby equipment. In addition, Loftus is supplying the fuel oil system, fire protection, and quench oil storage facilities.

Loftus Engineering Corp. also announced that construction is nearing completion on No. 35 and No. 36 open hearths at Jones & Laughlin's new South Side plant in Pittsburgh, Pa. Eleven 250-ton open hearths are under construction and are included in Jones & Laughlin's $200,000,000 improvement and expansion program. These open hearths were designed and constructed by Loftus.

Steel is scheduled to be tapped in October from No. 35 and No. 36. Of the four remaining to be completed in 1951, two will be in operation in

Greater Protection
for Vital Bearing Systems...



De Laval engineers know how to design a steel mill lubrication system that will offer the mill the maximum in bearing protection. This "know-how" starts with such fundamentals as applying the correct amount of lubricant to the proper point . . . knowing the most effective temperatures and pressures . . . and how best to meter the oil. But De Laval experience goes much deeper—takes all relative details into consideration—makes sure that the system is ***completely*** engineered. On one point De Laval is especially careful —to insure that every De Laval system is of large enough capacity to assure adequate cooling as well as efficiency of lubrication.

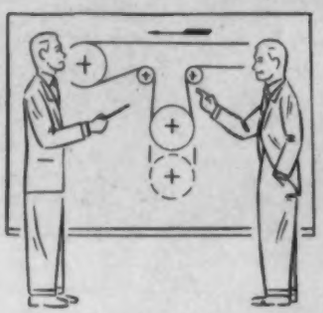
In De Laval Systems, purification of the lubricant is effected by means of the De Laval Oil Purifier. These machines, by centrifugal force, remove both solid and liquid impurities from the oil, and keep the rate of purification well in excess of the rate of contamination.

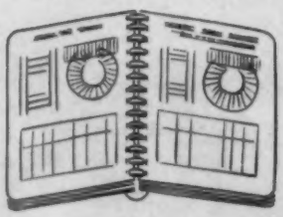
THE DE LAVAL SEPARATOR COMPANY
165 Broadway, N. Y. 6 427 Randolph St., Chicago 6
DE LAVAL SALES & SERVICE, INC.
447 Fourth Ave., Pittsburgh 19
DE LAVAL PACIFIC COMPANY
61 Beale St., San Francisco 5

DE LAVAL
Engineered Systems

➡ PURIFICATION OF LUBRICATING OIL
➡ PROPER APPLICATION OF LUBRICANT
➡ CORRECT METERING FOR LUBRICATION
➡ EFFICIENT TEMPERATURE CONTROL

SOUND ENGINEERING PRACTICE





● The conveyer system which does the best possible job is the system that was specifically designed to meet the requirements of that job. There is quite a lot of know-how in designing and fabricating conveying equipment, and no place for trial and error methods. It just costs too much to learn the hard way—by actual application—that equipment is too light, poorly constructed, or just improperly designed to do the work.

Mathews Conveyer Systems are made up of Power and Gravity Conveyers and special conveying machinery that is built on sound engineering principles—equipment that is designed to do a specific job well. That's why, when you are buying conveyers, whatever the application might be, you can be sure about this: If it's **Mathews equipment, it has to be right.**

Engineering offices or sales agencies are located in principal cities in the United States and Canada.

MATHEWS CONVEYERS

GENERAL OFFICES . . . . . *Mathews Conveyer Company*
ELLWOOD CITY, PENNSYLVANIA

PACIFIC COAST DIVISION . . *Mathews Conveyer Company West Coast*
SAN CARLOS, CALIFORNIA

CANADIAN DIVISION . . . . . *Mathews Conveyer Company, Ltd.*
PORT HOPE, ONTARIO

November and two in December. The other five will be in operation early in 1952.

Loftus is also erecting two open hearths at Jones & Laughlin's Otis works at Cleveland.

G-E ANNOUNCES NEW MAINTENANCE PLAN

▲ A new plan to help industry get the most productivity from its existing facilities has been announced by the General Electric Co.

Called "Productive Maintenance," the plan is designed primarily to assist maintenance engineers in setting-up a program to minimize lost production time and forced idleness due to equipment failures. In addition, it will provide better spare parts control, smoother production flow, and enable industry to gain optimum output from existing equipment, according to G-E engineers who worked on its development.

The term "Productive Maintenance" was chosen as a title for the over-all program in order to "take maintenance out of the realm of costly trouble-shooting," according to H. F. McCullough, manager of G-E's service shop division, "and place it where it really belongs — in the field of production as an operational asset."

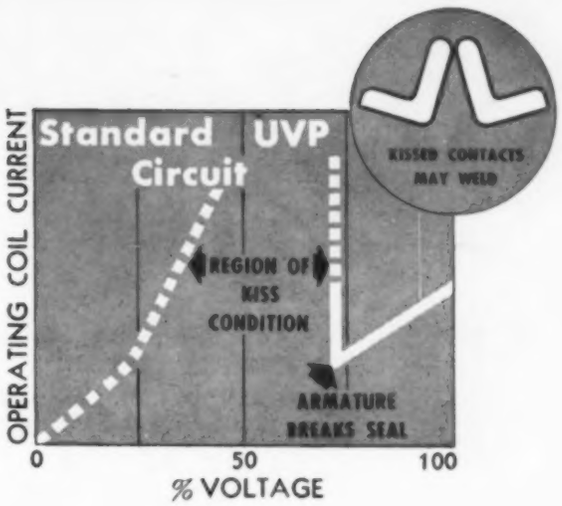
Productive maintenance, as outlined in G-E's plan, recommends (1) an adequate staff of trained maintenance men, armed with (2) the tools needed to perform properly the functions of (3) regular, routine checks of operating equipment, and (4) planned outage of this equipment at regular, scheduled intervals. Rebuilding and modernizing machines during time of planned outage is done readily with (5) an adequate stock of mechanical and electrical renewal parts. To help the maintenance engineer materially, the company offers a productive maintenance kit, a file-size package of maintenance aids to guide him in setting-up a working program. The kit contains an instruction bulletin, a typical balance sheet for keeping historical data on each machine, planned outage forms, and checklists for motors, control, and other equipment.

To supplement the kit, a new slide-film, "Productive Maintenance," will be available this fall for showing through the local G-E offices. The film

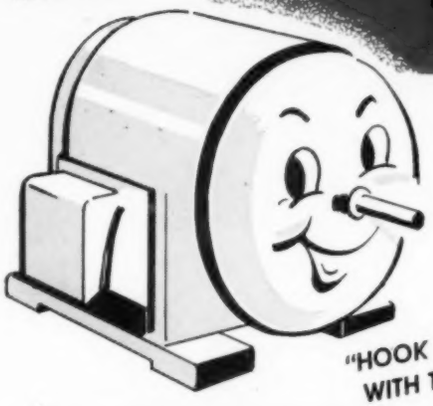
WHEN VOLTAGE DIPS—

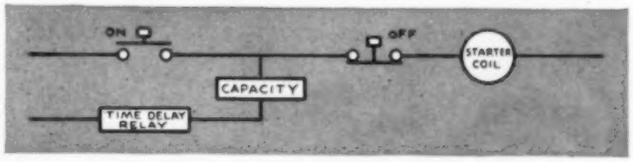
Here's what happens with the Standard Under-Voltage Protection Circuit:

1. Motor Starters open *lazily* when voltage drops (20 to 30% below normal).
2. Contacts may weld due to reduced spring pressure under low-voltage conditions.
3. When there is a complete loss of voltage, pressing buttons to restart essential motor drives is costly and time-consuming.

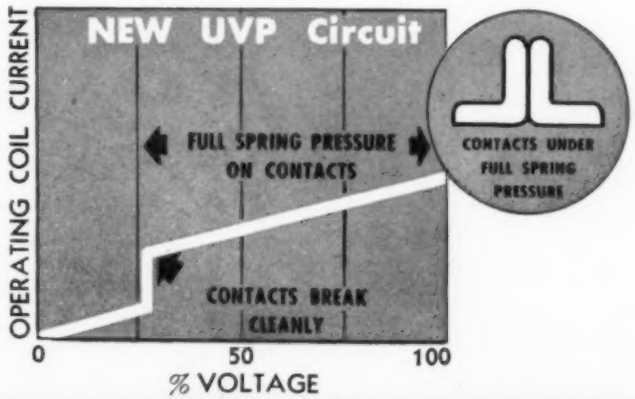


BUT NOW... A.C. Motor Starters are Electrically Locked-in and Will Start Automatically (If Normal Voltage Returns in 2 Seconds or Less)





Simple circuit — no mechanical latches or levers on starter-armature. Only the holding circuit is changed — time-delay of the holding circuit obtained by a simple relay of standard construction having one coil.



NO WELDING OF CONTACTS

This new time-delay UVP circuit uses standard 3-wire Push Button and gives these *advantages:*

1. Starters stay closed under full spring pressure down to a low voltage.
2. When voltage drops to about 75% below normal, contacts break cleanly in opening.
3. Essential drives keep running — by means of an exclusive control method motors *automatically restart* if voltage returns in 2 seconds or less.

Both low and high voltage EC&M Motor Starters are available with this new EC&M UVP Circuit.

WORTH LOOKING INTO—
ask for Accelerator Bulletin No. 30

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO

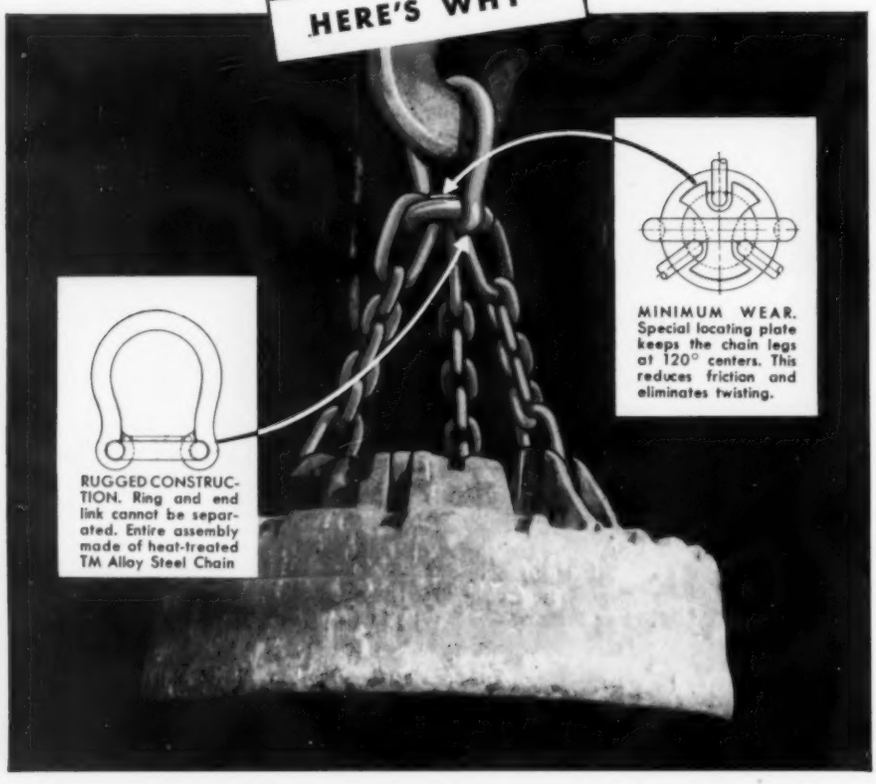
TM *Alloy Steel Downtown*

Frictionless
MAGNET CHAINS

DO MORE WORK, LAST LONGER,

COST LESS than conventional types!

HERE'S WHY—


MINIMUM WEAR. Special locating plate keeps the chain legs at 120° centers. This reduces friction and eliminates twisting.
RUGGED CONSTRUCTION. Ring and end link cannot be separated. Entire assembly made of heat-treated TM Alloy Steel Chain

Extensive on-the-job tests prove TM Alloy Steel Downtown Magnet Chains superior to any other three-leg assemblies on the market. Patented design of end link and horizontal ring with special locating plate keep chain legs at 120° centers. This prevents ganging-up, excessive friction and twisting . . . assures level lifts and even distribution of load weights. Additional long life, safety and economy is assured by Heat-Treated TM Alloy Steel Construction. High tensile strength, great resistance to abrasion, grain growth and shock at sub-zero temperatures are only a few of the TM Alloy Steel qualities. Send coupon today for details!

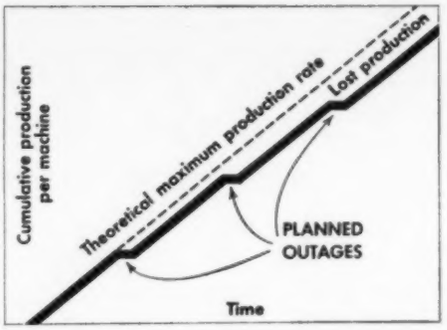
S. G. TAYLOR CHAIN COMPANY, Hammond, Indiana

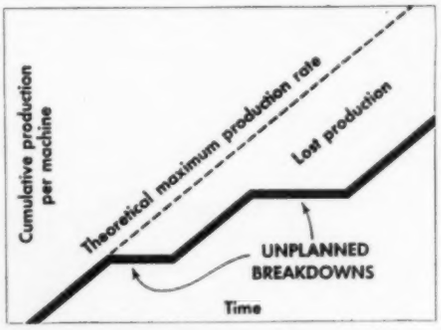
S. G. TAYLOR CHAIN COMPANY
Dept. 5 Hammond, Indiana
Rush literature and prices on TM Alloy Steel Downtown Magnet Chains.

NAME _____

ADDRESS _____

TAYLOR MADE
A GREAT NAME IN
Chain SINCE 1873





Charts illustrate how productive maintenance can increase production by cutting lost production due to unscheduled equipment outage.

explains how productive maintenance can benefit every industrial plant.

To further aid maintenance engineers establish productive maintenance programs, G-E service engineers, upon request, will assist in making a complete equipment survey to determine existing conditions, future outages, and to guide in setting-up a working spare parts control.

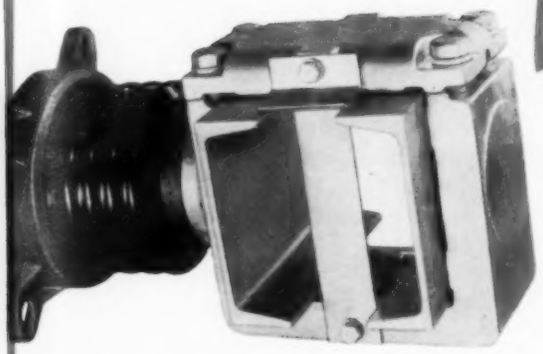
ATLANTIC STEEL EXPANDS AT ATLANTA, GEORGIA

▲Atlantic Steel Co., Atlanta, Ga., broke ground last week for the first phase of a multi-million dollar expansion program designed to keep in step with the growing demand for steel products in the southeast.

The first unit of the expansion program will be an electric furnace with an annual capacity of 100,000 tons of steel. This furnace will supplement the company's three present open-hearth furnaces, and will increase Atlantic Steel's annual capacity by 50 per cent, to 300,000 tons.

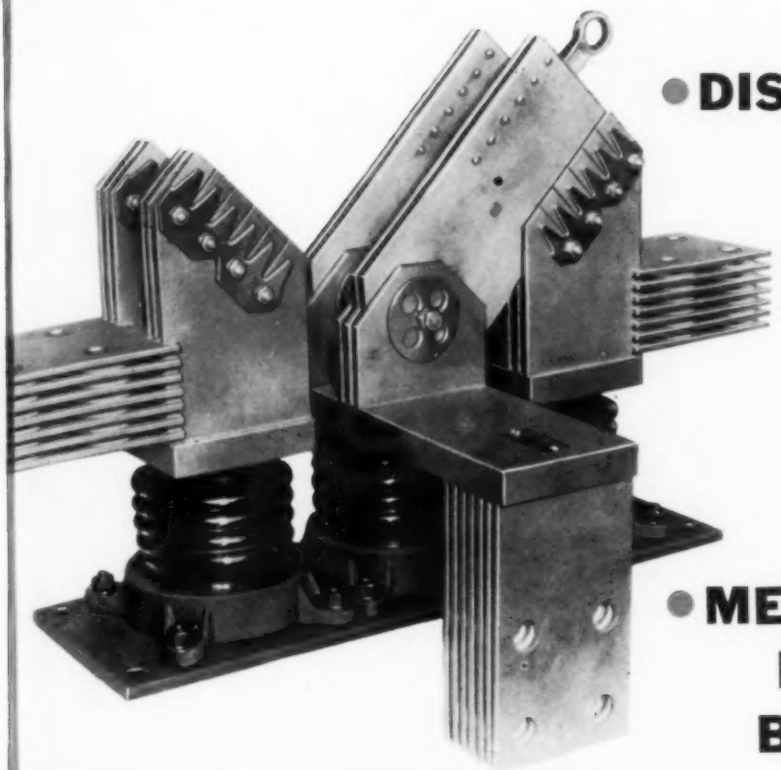
Excavation for the footings and floor of the huge building are now underway, by Strother-Barge Co., of Atlanta, and will be completed within six to eight weeks. The building itself, to be fabricated and erected by Bethlehem Steel Corp., will be 200 ft

CHECK the FACTS on R&IE



• BUS SUPPORTS

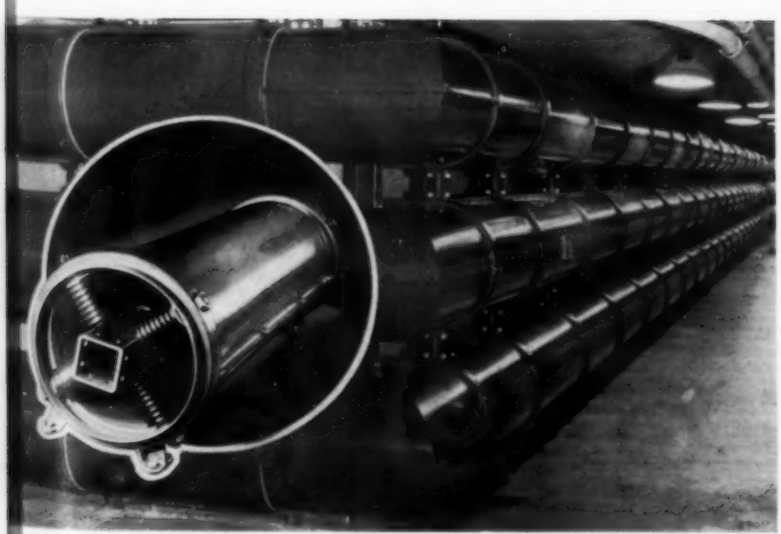
clamping two sections of five inch aluminum channel bus. Also designed for bus bar or cable support. Can be mounted in any position. Bus hardware attached with resilient alloy in place of cement — eliminating spot loading.



• DISCONNECTING SWITCHES --

double throw, 5,000 ampere rating. Blades are equipped with Hi-Pressure Contacts at operating end and at the hinge. Hi-Pressure Contacts make clean and positive electrical and mechanical current connections, and provide easy operation, free from sticking or freezing.

• METAL ENCLOSED ISOLATED PHASE BUS STRUCTURES



have sealed individual housings that prevent interphase short circuit. Support rings, as shown in circle, equalize all stresses. Covers can be removed for inspection or alterations. Especially suitable for heavy bus runs where mill dust and contamination is a problem.

Conductor can be round, square or bar.

Write for further details

RAILWAY AND INDUSTRIAL ENGINEERING CO., Greensburg, Pa.

Sales offices in all principal cities

The Check List

HORN GAP SWITCHES

CONDUCTOR SUPPORTS CLAMPS AND FITTINGS

DISCONNECTING SWITCHES INDOOR AND OUTDOOR

INTERRUPTER SWITCHES

CUTOUTS AND THERMO-RUPTERS

DISTRIBUTION EQUIPMENT

SWITCH OPERATING MECHANISMS

SUBSTATIONS

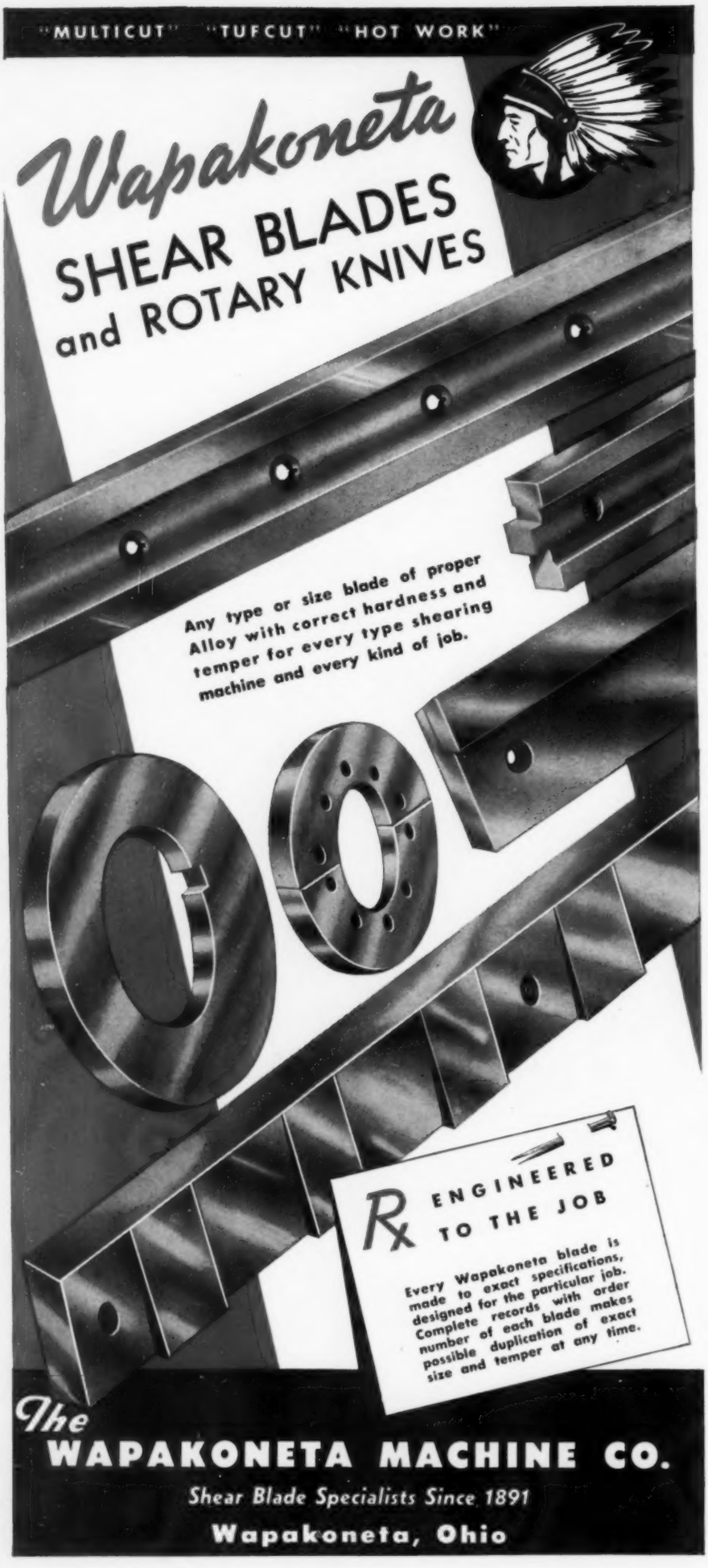
OPEN OR ENCLOSED ISOLATED PHASE HEAVY DUTY BUSES

KIRK INTERLOCK SYSTEMS

AUTOMATIC SWITCHING EQUIPMENT

METAL CUBICLES

TESTING DEVICES


"MULTICUT" "TUFCUT" "HOT WORK"
Wapakoneta
SHEAR BLADES
and ROTARY KNIVES
Any type or size blade of proper Alloy with correct hardness and temper for every type shearing machine and every kind of job.
TOOL
Rx ENGINEERED TO THE JOB
Every Wapakoneta blade is made to exact specifications, designed for the particular job. Complete records with order number of each blade makes possible duplication of exact size and temper at any time.
The WAPAKONETA MACHINE CO.
Shear Blade Specialists Since 1891
Wapakoneta, Ohio

long by 135 ft wide, and will stand 90 ft high. Craneways for the handling of scrap and ingots will be located at each end. The 60-ton furnace is being constructed by Pittsburgh Lectromelt Corp., and will be the largest electric furnace in the southeast.

Robert S. Lynch, president of Atlantic Steel, said the new furnace will provide the additional quantities of carbon steel necessary to keep the company's present finishing mills producing at capacity.

"It will also give us facilities for producing such special steels as tool steels and aircraft steels, for which there is an ever-increasing demand in the south," said Lynch.

LONE STAR BUYS ELECTRICAL DRIVES

▲ Westinghouse Electric Corp. has been awarded a contract for more than $900,000 by the Lone Star Steel Co. for auxiliary electrical drive equipment for the company's new universal slabbing mill at Lone Star, Texas.

The 45-in. × 80-in. mill will be equipped with dual gearing and clutch arrangements so that it can be used to reduce ingots to slabs, or slabs to plates. It will operate at a maximum rolling speed of 944 fpm.

The Westinghouse equipment consists of 28 adjustable-voltage auxiliary drives, 38 constant-voltage, direct-current auxiliaries, and 14 alternating-current auxiliaries, with a combined rating of 6245 hp.

A pair of 200-hp motors will operate the screwdowns for slabbing mill operation, and a pair of 75-hp motors will be used for plate mill operation.

Slabs and plates produced in the new mill will be further processed by Lone Star Steel Co. in a four-high reversing hot strip mill.

U. S. STEEL ORDERS NEW COKE OVENS

▲ United States Steel Co. has awarded Koppers Co., Inc., a contract for engineering and construction of three new batteries of chemical-recovery coke ovens, each comprised of 61 ovens.

The ovens will be constructed at United States Steel's Clairton, Pa., works which has the largest chemical-

ETABLISSEMENTS CHARLES COQUILLARD
ALUMINIUM MINCE
LAMINAGE BY TRANSFORMATION
HYDROPRESS, Inc.
570, Lexington Avenue 570
NEW YORK 22 N.Y.
Gentlemen:
We ordered from you, in February 1948, an installation for the rolling of aluminum strips and thin foil:
Width..... 1,000 mm (40")
Thickness.... 9/1000 (.00035")
Weight..... 1,200 kg (2650 lbs.)
Speed..... 1,000 m/min. (3280 ft./min.)
We are pleased to advise you that this complex material, received in June 1950, was put into operation in November 1950, after having been erected by ourselves without great difficulty.
This material gives us entire satisfaction and its production will be four times greater than the estimated output guaranteed by your contract.
We authorize you to make use of this attestation.
Please accept, Gentlemen, the expression of our kindest regards.
This material gives us entire satisfaction and its production will be four times greater than the estimated output guaranteed by your contract.

LOEWY HIGH SPEED ROLLING MILLS

FOR STRIP AND FOIL

- *speed more than 3000 FPM*
- *designed for one-man operation*
- *extremely sensitive tension & temperature control*

Four-High Cold Strip Mill For Roughing Aluminum Foil. A part of the High-Speed Cold Rolling Mill Installation for the production of aluminum foil 42" wide and .00025" thick supplied to Etablissements Charles Coquillard, France.

We were the first designers of High-Speed Foil Mills in 1945. Since then many details of our design have been greatly improved and tested in actual production.

We supply complete Rolling Mill Installations and the specialized Auxiliary Equipment that is indispensable for high-speed production of foil and other strip material to accurate gauge.

LOEWY ROLLING MILL DIVISION

HYDROPRESS Inc.

ROLLING MILLS AND ROLLING MILL EQUIPMENT

566-568 Lexington Avenue General Electric Bldg. at 51st Street **New York 22**

CHICAGO • DETROIT • SAN FRANCISCO • SEATTLE • WASHINGTON, D. C.

recovery coke plant in the world, and the three batteries will replace three old batteries which have been in use for many years. They will carbonize approximately 4200 net tons of coal per day.

Plans call for Koppers to start work on the engineering soon and actual construction work on one battery will probably get under way before the end of the year. The second battery will be started one month after the first, and the third battery six months after that.

Each of the new ovens will have a charging capacity of 18 tons of coal, and a coking cycle of 18 hours for each charge.

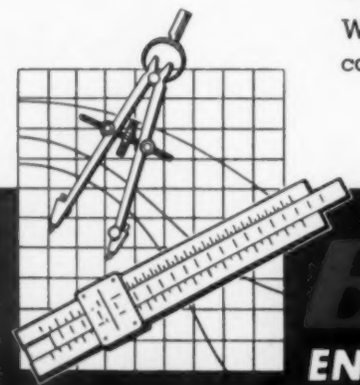
Present equipment for handling tar and light oils from the new batteries will be utilized.

TUBE FIRM BUILDING NEW MANUFACTURING UNIT

▲ Precision Tube Co. of Philadelphia has just announced plans for a new manufacturing plant and office building to be located at North Wales, Pa. The plant will be of the latest design for the most efficient production of non-ferrous seamless tubing of sizes from 0.500 to 0.010-in. outside diameter. The plant will cover an area of 21,000 sq ft and will be completely equipped with the latest type of equipment, including overhead electric cranes, newly designed straightening machines, the latest in draw bench equipment, and additional modern gas and electric fired annealing furnace capable of handling 2000 lb of tubing per hour and many new innovations in the production of fine seamless tubing. The front part of this modern building will house the executive offices on the second floor, while the first floor will be devoted to a control and engineering laboratory to assist customers in solving their many types of tubing problems.

Designed for specialized applications, the new Bloom HTR Burner will release up to 750,000 Btu per cubic foot of combustion volume. Exceptional results have been shown where quick heating and intense concentration of heat are required.

Write for Bulletin 1081 giving complete details.



BLOOM ENGINEERING CO., INC.

857 W. North Avenue Pittsburgh 33, Pa.

INLAND BUYS NEW SLAB REHEAT FURNACE

▲ A new slab reheating furnace will be built for Inland Steel Co. at its Indiana Harbor, Ind., works, by Rust Furnace Co.

The new multi-fired reheater, a zone-controlled, continuous type furnace, is being designed to deliver 85 tons of slabs per hour at a temperature of 2250 F. It is the third such furnace to be constructed by Rust at this works.

It will be end charged and discharged, fired with coke oven gas or fuel oil, and equipped with a recuperator and full automatic control for temperature and furnace pressure together with automatic fuel-air ratio.

Furnace design calls for an inside width of 18 ft and an effective length of 76 ft 10 in.

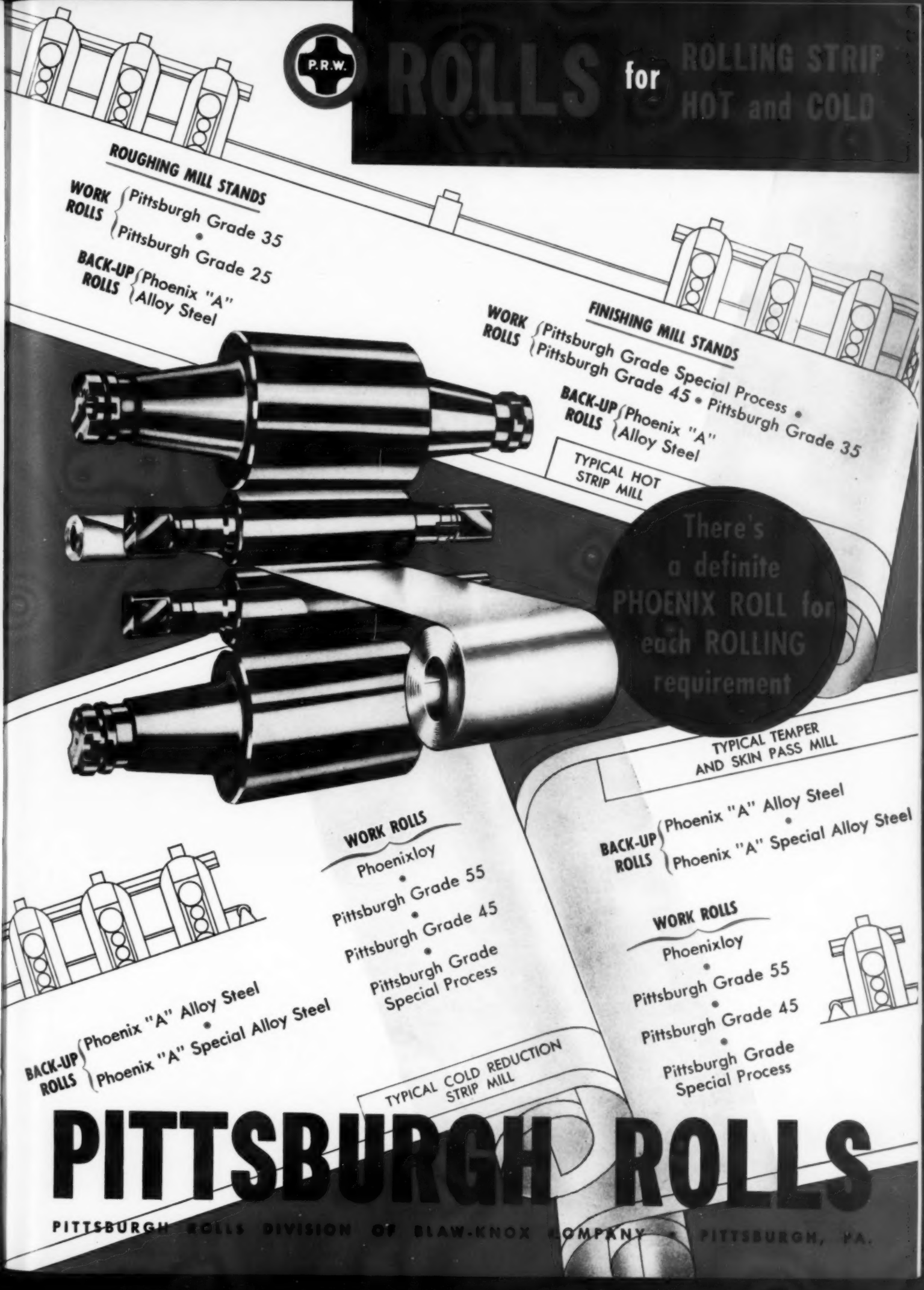
BUY ELECTRICAL DRIVES FOR HOT STRIP MILL

▲ More than $3 million of General Electric equipment, including mill drives totaling 22,000 hp, has been ordered by the Pittsburgh Steel Co. for its new hot strip mill at Allenport, Pa.

Erection of the new mill will mark the fourth major step in Pittsburgh Steel Co.'s planned program of expansion and modernization. Currently, the firm produces tubular, wire and semi-finished products, and has no flat rolled finishing facilities. At the conclusion of its expansion program, Pittsburgh Steel will be a producer of flat rolled products.

The program includes construction of a new blooming mill and a new hot strip mill, both under construction, and a cold rolled sheet mill. The

ROLLS for ROLLING STRIP HOT and COLD



ROUGHING MILL STANDS

WORK ROLLS { Pittsburgh Grade 35 • Pittsburgh Grade 25

BACK-UP ROLLS { Phoenix "A" Alloy Steel

FINISHING MILL STANDS

WORK ROLLS { Pittsburgh Grade Special Process • Pittsburgh Grade 45 • Pittsburgh Grade 35

BACK-UP ROLLS { Phoenix "A" Alloy Steel

TYPICAL HOT STRIP MILL

There's a definite PHOENIX ROLL for each ROLLING requirement

TYPICAL TEMPER AND SKIN PASS MILL

BACK-UP ROLLS { Phoenix "A" Alloy Steel • Phoenix "A" Special Alloy Steel

WORK ROLLS

Phoenixloy • Pittsburgh Grade 55 • Pittsburgh Grade 45 • Pittsburgh Grade Special Process

BACK-UP ROLLS { Phoenix "A" Alloy Steel • Phoenix "A" Special Alloy Steel

WORK ROLLS

Phoenixloy • Pittsburgh Grade 55 • Pittsburgh Grade 45 • Pittsburgh Grade Special Process

TYPICAL COLD REDUCTION STRIP MILL

PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION OF BLAW-KNOX COMPANY • PITTSBURGH, PA.

ACTION WITH BILLETEER AT CRUCIBLE STEEL OF AMERICA

Pictured below are Inspector J. R. Welford and Operator Antonio Gutierrez utilizing the finger-tip control and precision of the Bonnot Billeteer for billet-cleaning at the Midland plant of the Crucible Steel Co. of America.

Accurate Billet Conditioning is a prime requisite of steel production *for war or peace,* just as the A-B-C's are fundamental to general business. ● With a *Bonnot Billeteer* you are assured of ACCURATE, FAST, SAFE, MODERN billet-cleaning that also REDUCES COSTS, CUTS MANPOWER TURNOVER and PROVIDES BETTER BILLETS. ● As at Crucible Steel, Billeteer installations are Bonnot-engineered to meet individual plant needs. ● For performance facts, write today!

Engineered For Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO

Also Manufacturers of — SAWING • CRUSHING • PULVERIZING AND MIXING EQUIPMENT • BILLET INSPECTION TABLES
DUST PUG MILLS • SINTER PLANT PUG MILLS

blooming mill and the hot strip mill will feature G-E equipment.

General Electric equipment for the continuous hot strip mill includes a 6000-hp, reversing roughing mill drive and a finishing mill drive comprised of four, 4000-hp, d-c motors.

In place of the customary motor-generator sets, the finishing mill drive will be powered by two 5000-kw mercury arc rectifiers. Having no rotating parts, these rectifiers produce high efficiency at low maintenance costs for this type of operation, according to G-E engineers.

Power distribution equipment, laid out with future expansion needs in mind, includes three G-E transformers with an aggregate rating of 32,500 kva.

ALUMINUM ORE CO. INCREASES CAPACITY

▲Plans for increasing the nation's alumina producing capacity by 180,000 tons annually, through the addition of new production facilities at an existing plant in Mobile, Ala., were announced by Aluminum Ore Co.

Alumina (aluminum oxide) is the material obtained from bauxite ore as the major preliminary step in the production of aluminum and of alumina chemical products. About two pounds of alumina are used in producing one pound of aluminum.

Aluminum Ore Co. is also currently erecting a new alumina works at Bauxite, Ark., in addition to operating plants at Mobile and at East St. Louis, Ill.

The new construction program, together with the capacity being added in Arkansas, will boost the Alcoa subsidiary's alumina production capacity by approximately 70 per cent when completed. Construction at Mobile is scheduled to begin in the immediate future.

ALUMINUM RESEARCH LAB IS EXPANDED

▲ Aluminum Co. of America is expanding its research facilities with the erection of a new building at the company's Aluminum Research Laboratories at New Kensington, Pa.

The new unit — measuring 80 × 170 ft — is needed to relieve congestion and to extend their research facilities to meet increasing demands of the national defense program. It will increase total floor space at the laboratories by about one-third. Construction is already under way, and the building will be ready for occupancy early next year.

The new addition will consist of two bays, one of which will be three stories high, the other two stories. A six-ton mill-type crane will be installed in the first bay to handle heavy research equipment.

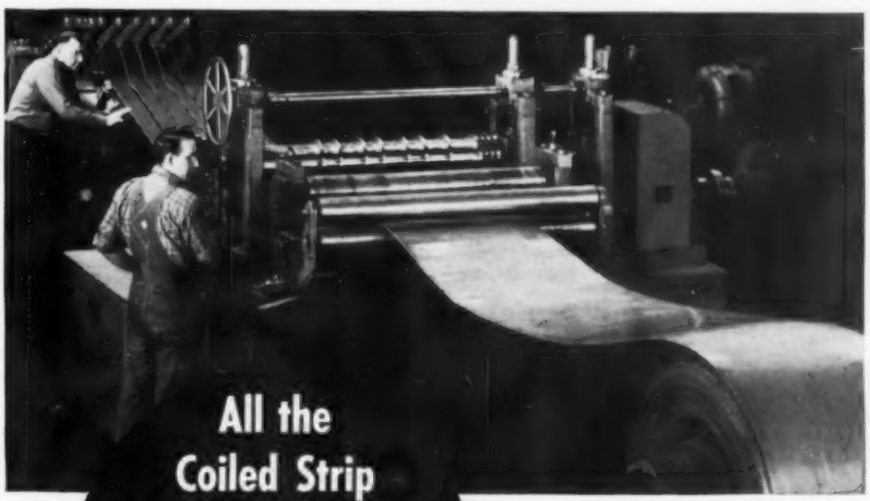
Reinforced concrete will be used from the footings to the second floor level. Brick facing will be used from there to the top of the building to harmonize with other buildings on the laboratory grounds.

In addition to the main laboratory at New Kensington, Pa., Alcoa also maintains laboratories at Massena, N. Y., Cleveland, Ohio, and East St. Louis, Ill. Massena investigates electrical problems; Cleveland handles foundry and forging problems; and East. St. Louis works with aluminum ore products. The New Kensington laboratory is headquarters dealing with all research aspects of the aluminum industry.

CANADIAN PLANT CHANGES OWNERSHIP

▲ Purchase of the St. Thomas, Ontario, works of Allis-Chalmers Rumely, Ltd., by Canadian Allis-Chalmers (1951), Ltd., was announced. The St. Thomas works was built in 1948. The plant was purchased by Allis-Chalmers Rumely from Erie Iron Works in September 1950.

Both Canadian Allis-Chalmers



All the Coiled Strip You Need...WHEN You Need it... At LOWER COST!

You will find it ever so much easier to have all these things when you install a Yoder Rotary Slitter. The sources of supply of mill-width stock are obviously much more numerous, prices per ton much lower, and deliveries much quicker than on slit-to-width strands.

Not only that, but your stock becomes more flexible—goes farther—when mill-widths can in a few hours be slit to the desired widths in your own shop. Many fabricators have reduced inventories from 40 to 60% by investing in a Yoder slitter. Production planning becomes easier, too, when expected and unexpected needs for any width can be so quickly and easily met.

Besides all these advantages, direct savings may range from $5.00 to $50.00 per ton, depending on widths, quantities and other factors. On requirements as low as 1000 tons per year, a Yoder slitter often becomes a most profitable production tool. Get the facts! Send for 78-page book on the Economics as well as the Mechanics of doing your own slitting.

THE YODER COMPANY • 5495 Walworth Ave., Cleveland 2, Ohio

Complete Production Lines

- ★ COLD-ROLL-FORMING and auxiliary machinery
- ★ GANG SLITTING LINES for Coils and Sheets
- ★ PIPE and TUBE MILLS—cold forming and welding

ENGINEERING YODER MANUFACTURING

(1951) and Allis-Chalmers Rumely are subsidiary firms of Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

COLLEGE PROFESSORS AID TRAINING PROGRAM

▲ Nineteen college professors—representing the leading engineering colleges of the country—are augmenting their text-book knowledge this summer by working side-by-side with engineers and workmen of the Westinghouse Electric Corp. The Industrial Experience Program, begun by Westinghouse several years ago, not only gives such professors the opportunity to practice what they teach, but furnishes them with an insight into the engineering needs and problems of American industry.

The principal object of the program is the development of a more competent engineering graduate, and one who can more easily make the transition from the campus to the ranks of industry.

The 19 professors who are spending the summer months with Westinghouse are paid a regular salary by the company and are given assignments relating to their particular fields of study. The men work closely with company engineers, and have considerable latitude in contacting the shops and other departments.

LARGE SULPHUR DEPOSIT FOUND IN RIVER DELTA

▲ Discovery of a large new deposit of sulphur which is expected to be a major factor in solving the current world shortage of this essential mineral was announced by Freeport Sulphur Co.

To develop the deposit, located at the mouth of the Mississippi River, Freeport will build a $10,000,000-$15,000,000 mining plant having a production goal of 500,000 long tons of sulphur a year.

The mine, the largest single sulphur development anywhere in the world in nearly 20 years, is expected to be ready for operation in 1953.

ANNEALING LINE USES LARGE CONTROL GROUPING

▲ The largest single grouping of a-c control especially designed for steel mill use was built recently by General Electric's control divisions for the new continuous strip annealing line of United States Steel Co. at Gary Ind.

The front-connected, enclosed line-up of a-c control is 15-in. deep, 90-in. high, excluding floor sill and lifting beam, and extends to an over-all length of 106 ft. According to G-E engineers, it employs the most modern external disconnect handles, safety-interlocked with the door of each compartment. It also features 600-amp horizontal buswork in an isolated bottom compartment, easily accessible wiring troughs, and G. E.'s new magnetic switches, they said.

In addition to the a-c group control center, General Electric supplied the U. S. Steel mill with photoelectric-amplidyne loop control, and 92 ft of d-c variable-voltage control arranged in a back-to-back line up.

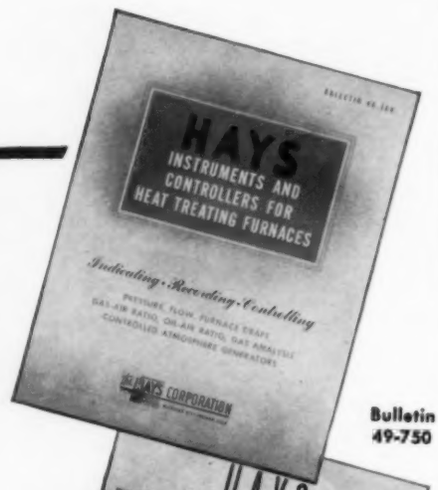
The processing line was designed to operate at a speed of 1000 ft per min with an output of 30 tons per hour.

Bulletins on instruments and control for 2 types of furnaces

HEAT TREATING FURNACES

A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages, and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.

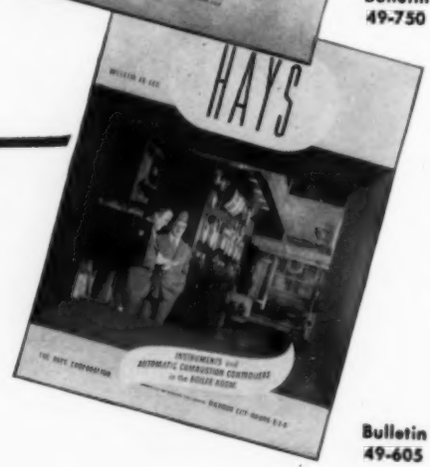


Bulletin 49-750

BOILER FURNACES

This bulletin summarizes applications of Hays centralized combustion control to chain grate, underfeed, spreader type, or lever type stokers; to attritia type, bowl type or ball bearing type pulverizers; to a wide range of oil burners including the rotary cup; and to a wide range of gas burners.

The Hays complete line of draft gages, flow gages, and meters (for high and low pressure gases and liquids), portable gas analyzers, automatic CO_2 recorders, and electronic type O_2 recorders are covered.



Bulletin 49-605

Write for these informative bulletins today.

THE **HAYS** CORPORATION

MICHIGAN CITY 13, INDIANA

combustion and industrial instruments and control

P&H MILL TYPE CRANES

. . . with all the P&H ADDED VALUES *Steel Men want!*

Three Gear Case Bridge Drive
delivers motive power to end trucks, perfectly equalized. Mill motor is connected to gear case at center of span, which transmits power equally to the gear cases in front of each end truck.

No Open Gears at Trucks—
gear reductions are completely enclosed in sturdy all-welded cases. All gears run in oil — quietness and long life are insured with all gears operating in oil baths. No exposed gears; no dripping grease.

Flexible Couplings at Wheel Shafts
assure smoother starts — maximum bearing life and prevent thrust from entering gear cases.

Split Gear Cases
are designed to simplify inspection and maintenance.

Large Diameter Cross Shaft
combines maximum strength with low torque to minimize strain.

Hoist Sheaves
readily accessible from trolley deck. All hoist gears, including drum gear and pinion, run in oil.

Trolley Frame
and bridge ends are line bored and milled.

P&H Motors,
brakes and controls are available.

These and many other Added Values explain the preference which accounts for more than 2,000 P&H Cranes in steel mills. P&H Mill Type Cranes are described in Bulletin C-42. Ask for your copy.

P&H **OVERHEAD CRANES**
4455 West National Avenue
Milwaukee 14, Wisconsin
HARNISCHFEGER CORPORATION

POWER SHOVELS • CRAWLER AND TRUCK CRANES • OVERHEAD CRANES • HOISTS • ARC WELDERS AND ELECTRODES • SOIL STABILIZERS • DIESEL ENGINES • PRE-FAB HOMES

Cold rolled steel strip is fed from payoff reels, through pinch rolls, welding stations, cleaners, and entry loops to the furnace where the heat annealing process takes place. The steel travels through the furnace in a continuous strip made possible by the welding together of successive coils.

G-E amplidyne control helps maintain uniformity of product by providing accurate regulation of speed. Combined with photoelectric control, it makes possible optimum looping action so that an unbroken strip is supplied to the furnace. Finally, amplidyne controlled tension regulation enables the annealed steel to be coiled in uniformly wound reels for better handling in subsequent processes.

The d-c control for this multi-section, variable-voltage drive is constructed on an open, back-to-back "H" framework with all resistors mounted and wired in overhead racks. This type of construction helps save precious motor room space, the engineers said, while still affording all the advantages of a completely factory-assembled, self-supporting structure.

NPA STUDIES CRANE ORDER ESSENTIALITY

▲ A method of determining the relative essentiality of orders for cranes now on their books was urged by the Overhead Traveling Crane Industry Advisory Committee at a meeting with officials of the National Production Authority, U. S. Department of Commerce.

The committee told NPA that the industry now has a delivery lead time of from 15 to 17 months on standard size cranes and from 22 to 24 months on heavy cranes. In normal times this backlog would be only from six to eight months, members said.

The committee pointed out that more than 90 per cent of these orders carry DO ratings. Unless some way is found to indicate which are most essential to the defense effort, confusion and disruption of production schedules will develop, committee spokesmen warned. NPA agreed to consider the suggestion.

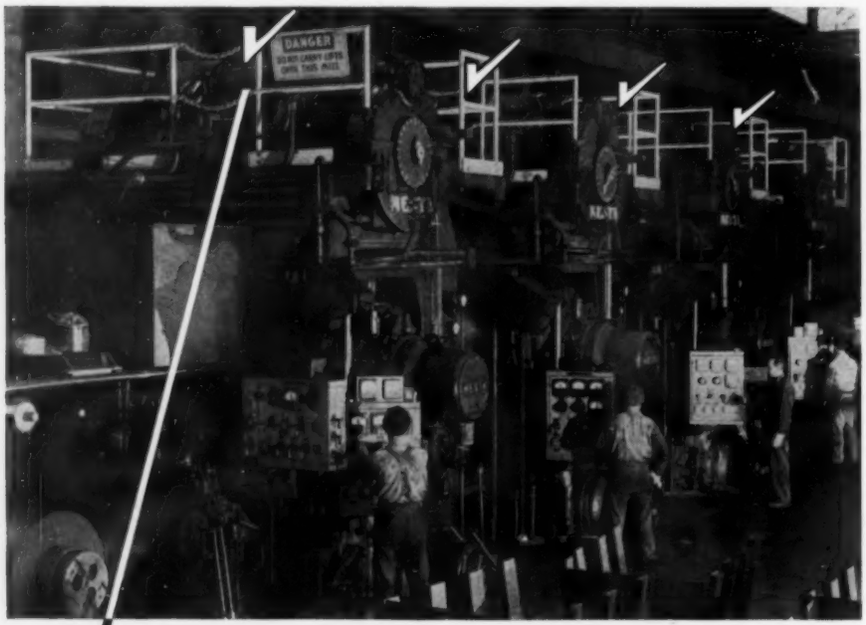
NPA said it is studying the necessity of freezing periodical schedules of production at some future date. The committee expressed no objection, stating that it would give its concurrence to such an order if NPA regarded the move as beneficial to the industry generally.

NPA officials, in discussing the present supply of certain critical materials, stressed that steel and copper would be in short supply for sometime. Aluminum supplies should increase during the first quarter of 1952 because new aluminum facilities will be in production by then, NPA said.

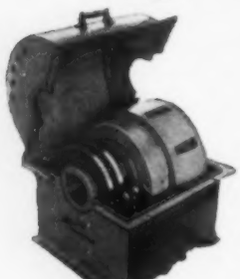
REFRACTORY WAREHOUSE OPENED IN CHICAGO

▲ Opening of the newly constructed Chicago, Ill., sales warehouse of the General Refractories Co. was announced. The warehouse which contains 10,000 sq ft of storage space will house a complete line of clay, silica, basic and sillimanite brick, specialties, and industrial insulations and related products. The building also incorporates latest materials handling features and contains heated storage spaces for wet cements and mortars.

(*Please turn to page 280*)



Stearns KEEPS THEM ROLLING AT ALLEGHENY LUDLUM



STEARNS Style "E" Multiple Disc Magnetic Clutch fully enclosed in steel housing for steel mill application.

Synchronizing the drives of the screwdowns of a large mill requires a rugged, dependable clutch — a STEARNS Multiple Disc Magnetic Clutch. That's exactly the story of this installation, told *four* times! On each stand of this Mesta four high cold rolling mill at the Allegheny Ludlum Steel Corp., West Leechburg, Pa., there is a STEARNS Magnetic Clutch to synchronize the screwdown drives.

The newest and most powerful for its size, it is natural that this strip mill incorporate STEARNS Magnetic Clutches. Designed for just such steel mill applications, the STEARNS clutch is a low inertia unit of simple construction with no toggles, pins, yokes, shifters or other parts to wear and get out of order. Controlled by a push-button station, STEARNS clutches are available with taper-bores, detachable magnet hub, torques and construction to meet your screwdown requirements.

STEARNS EQUIPMENT FOR STEEL MILLS

Circular and Rectangular Lifting Magnets
Sheet and Pipe Conveyor Rolls
Magnetic Brakes and Clutch-Brakes
Drag Magnets and other steel mill magnetic specialties

Stearns MAGNETIC MANUFACTURING CO.

681 S. 28th St., Milwaukee 46, Wisc.

Photograph of Palmer-Bee Upender transferring 72,000 lb. Coils to P-B Flat Top Coil Conveyor. P-B Upenders, with capacities up to 75,000 lb. are built with Extra-Heavy Plate Construction and Heavy duty High-Pressure Hydraulic action—assuring smooth, efficient operation—*Year after Year.*

FOR STEEL MILL CONVEYORS and EQUIPMENT

to take the added punishment of HIGHER PRODUCTION

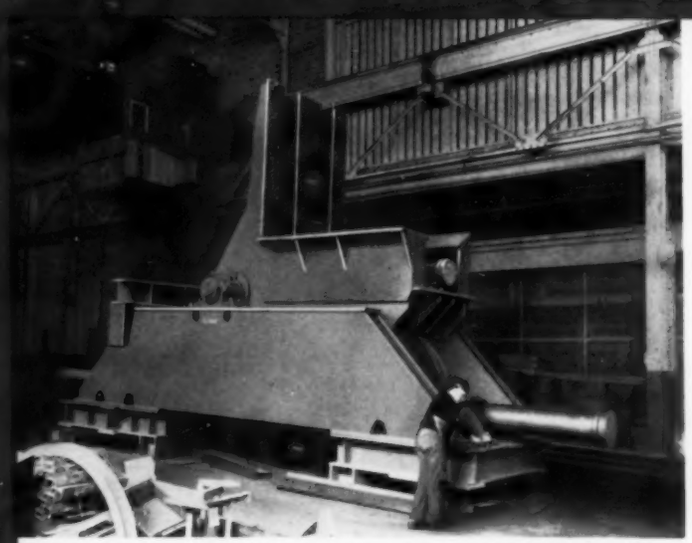


Photo Shows Upender under construction. Weighing 88,000 lbs., it is one of a group of six in this installation. The major portion including Heavy Duty High-Pressure Hydraulic operating mechanism of this upender (or down-ender) is below floor level.

The Upender and Conveyor system, pictured above, engineered and built by Palmer-Bee, is the first of a group of six complete units.

These giant upenders, designed to tilt, turn, lift, or lower coils are fabricated of heavy plate with oversized Heavy-Duty, High-Pressure, Hydraulic units that operate on the balanced push-pull principle, built for rugged Steel Mill Service.

The Heavy duty Flat Top Coil Conveyors are designed to carry heavy loads—up to 75,000 lbs.

Production planning to meet greater tonnage schedules becomes easier when unexpected needs can be met on such equipment designed for heavy production.

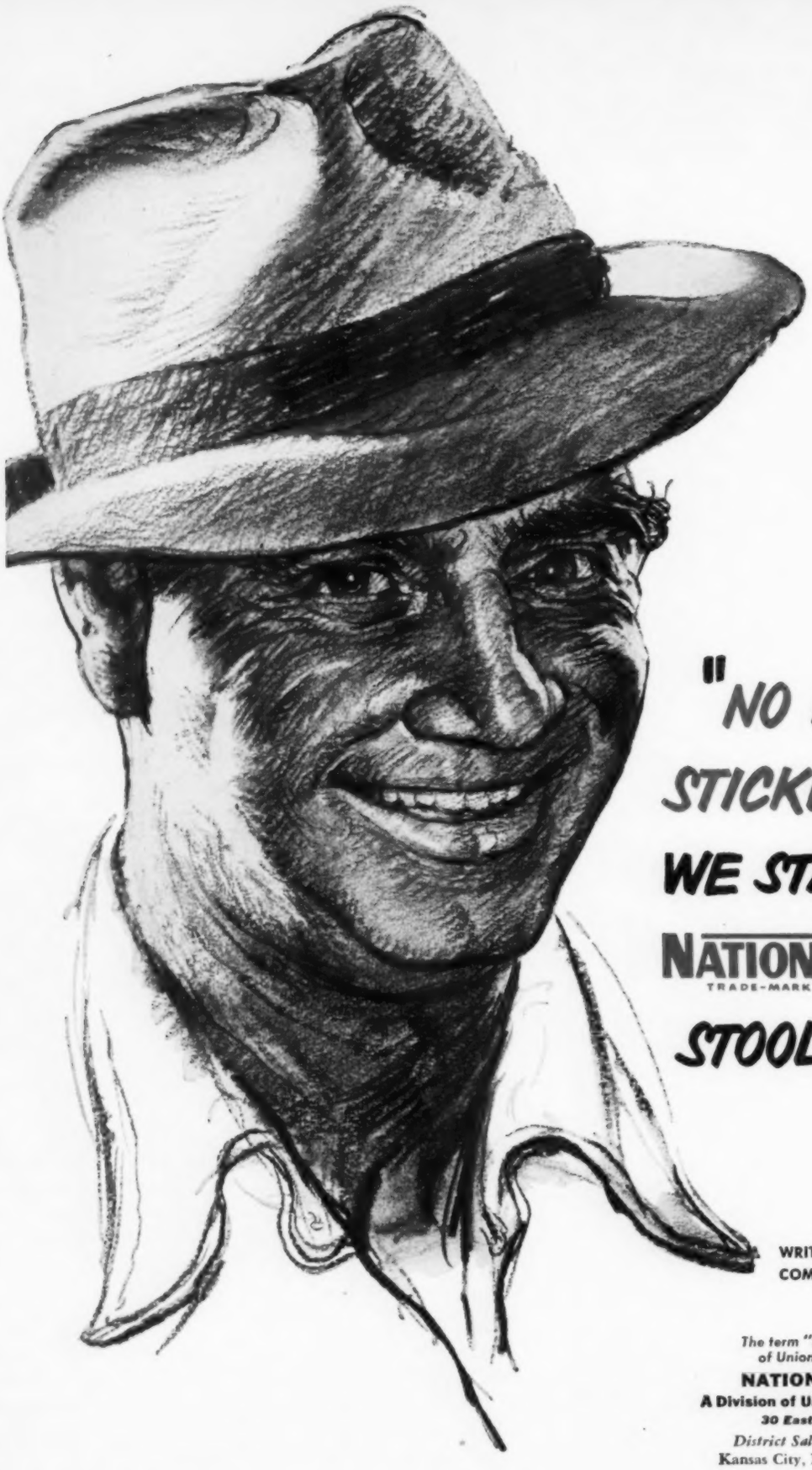
Throughout industry Palmer-Bee Conveyor equipment is meeting the needs of the national emergency for higher production schedules.

First in Service to the Steel Industry.

PALMER-BEE COMPANY

DETROIT 12, MICHIGAN

BELT CONVEYORS • BELT & BUCKET ELEVATORS • STEEL MILL CONVEYORS • SCREW AND SPIRAL CONVEYORS
MINE, MILL & FOUNDRY EQUIPMENT • SKIP HOIST MACHINERY • SPEED REDUCERS • GRAVITY ROLLER CONVEYORS
BULK MATERIAL HANDLING CONVEYORS • OVERHEAD CONVEYORS • POWER TRANSMISSION MACHINERY



"NO MORE STOOL STICKERS... SINCE WE STARTED USING NATIONAL TRADE-MARK GRAPHITE STOOL INSERTS!"

WRITE TO NATIONAL CARBON COMPANY FOR INFORMATION.

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
IN CANADA: National Carbon Limited
Montreal, Toronto, Winnipeg

Other NATIONAL CARBON products

BLAST FURNACE LININGS • BRICK • CINDER NOTCH LINERS • CINDER NOTCH PLUGS • SKIMMER BLOCKS • SPLASH PLATES • RUNOUT TROUGH LINERS • MOLD PLUGS • TANK HEATERS

Personnel News...

John A. Hagan has been appointed general superintendent of Homestead, Pa., district works of United States Steel Co. Mr. Hagan succeeds **H. G. McIlvried** who is retiring after more than fifty years' service with U. S. Steel. Since December 1950 Mr. Hagan has been assistant general superintendent of Youngstown, Ohio, district works. Mr. McIlvried started his career with United States Steel in May 1901. His first job was as machinist and draftsman at the Rankin, Pa., works of American Steel & Wire Co. After a number of promotions involving employment with National Tube Co., Carnegie Steel Co. and American Sheet and Tinplate Co. he was made assistant manager of operations for the Chicago district of Carnegie-Illinois Steel Corp. when that company was formed in 1936. On February 15, 1937, Mr. McIlvried was transferred to Pittsburgh as assistant to the manager of operations, Pittsburgh district, in which position he was responsible for the construction of Irvin works, Dravosburg, Pa. On completion of Irvin works, he was appointed first general superintendent of the new plant. On May 1, 1940, he was transferred to Homestead as general superintendent.

Charles E. Pritchard was appointed superintendent of finishing mills for the Alan Wood Steel Co., Conshohocken, Pa. Mr. Pritchard was formerly chief lubrication engineer for the Republic Steel Corp., Cleveland, Ohio. In his new job, Mr. Pritchard will be responsible for the production and shipping of product from all finishing mills. Mr. Pritchard is also very active in the affairs of the Association of Iron and Steel Engineers having served on the Board of Directors, chairman of the lubrication division, and also as chairman of the Plain Bearing Committee, which recently developed an AISE Recommended Practice for Plain Bearings.

William L. Fader was named general superintendent at Christy Park works of National Tube Co. at McKeesport, Pa. He succeeds the late Arthur C. Landis. Mr. Fader had been assistant general superintendent since December, 1950.

C. P. Betz was appointed general manager of Hanna Furnace division, Great Lakes Steel Corp., Ecorse, Mich. Mr. Betz had been serving as assistant general manager.

William B. Pierce has been elected a vice president of Allegheny Ludlum Steel Corp., Pittsburgh, Pa. Mr. Pierce, who joined the company in 1945 as manager of the sales development and engineering service department, was named technical director in December 1950, when he was given responsibility for research and metallurgical activities. He will retain that position as a vice president.

George I. Ziders has been appointed industrial plant engineer for the Sanderson-Halcomb works of Crucible Steel Co. of America in Syracuse, N. Y. For the past ten years, Mr. Ziders has been associated with the Donora steel and wire works of the American Steel & Wire Co. His most recent position was that of division industrial engineer where he had charge of industrial engineering activities in one section of the plant.

D. G. Holt was appointed assistant superintendent, mechanical maintenance, Crucible Steel Co. of America, Midland, Pa. For the past two years Mr. Holt has been general maintenance superintendent, Companiade, Acerodel Pacifico in Chile.

Raymond H. Armour was named to the newly created post of operating priorities representative in the American Steel & Wire Co.'s production planning department.

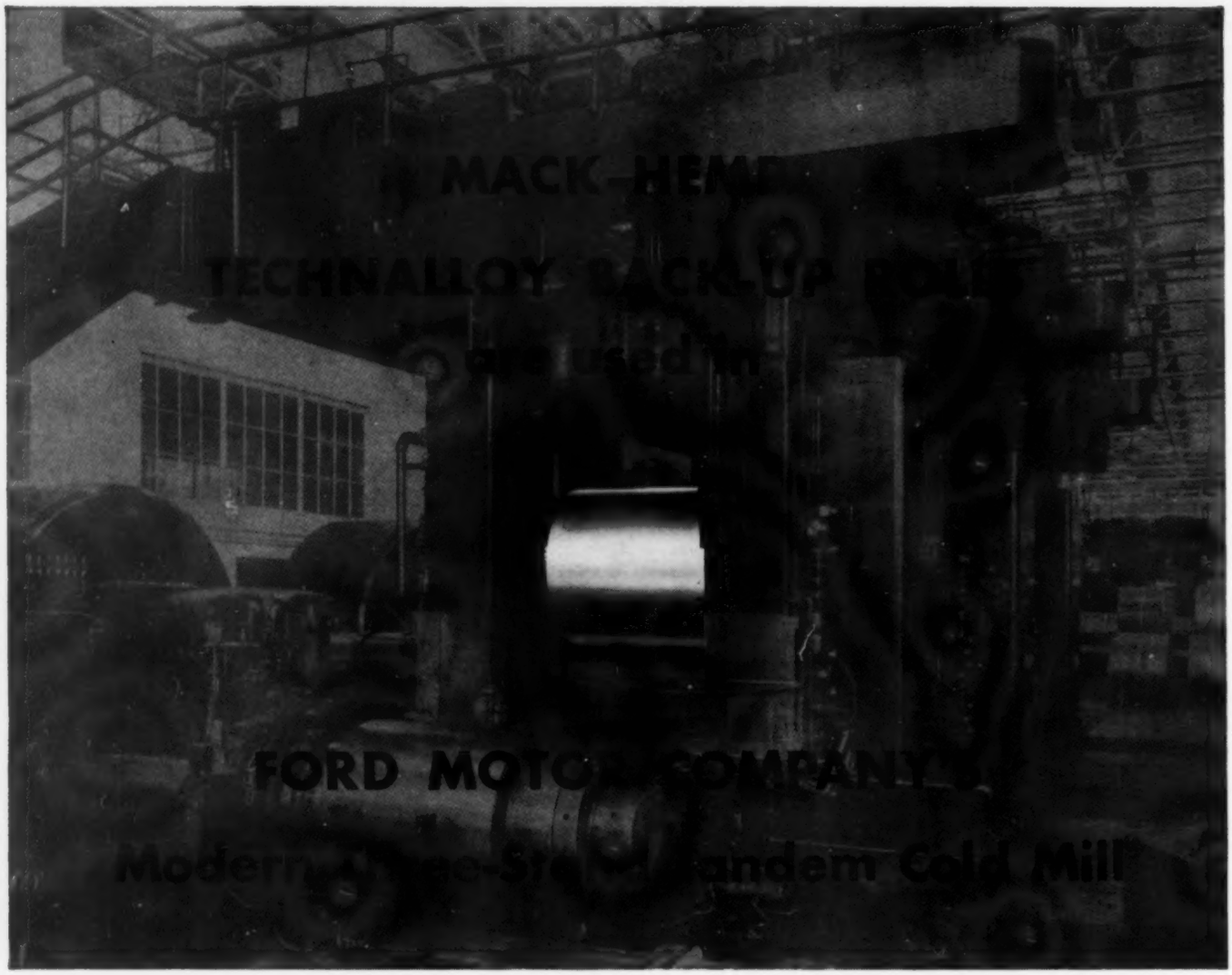
Edwin H. Howell has been appointed assistant manager of the East Central district of the General Electric Co.'s apparatus marketing division. Headquarters of the district are at Cleveland, Ohio.

JOHN A. HAGAN

H. G. McILVRIED

CHARLES E. PRITCHARD

WILLIAM L. FADER



The efficient, modern cold mills at River Rouge Plant are equipped to supply the rigid specification steels for Ford Motor Company products.

In this 3-stand mill, the rolls *with the striped red wabblers*—49" x 66" Technalloy Rolls—are used for back-up in strip mill productioneering. In other steel-making operations at Ford Motor Company, rolls *with the striped red wabblers* are used for rolling hot strip and in blooming mills.

And it's the same story, day after day, wherever Mack-Hemp Rolls are used—the rolls *with the striped red wabblers* set the productioneering pace.

MACKINTOSH-HEMPHILL

COMPANY

Makers of the Rolls with the Striped Red Wabblers

PITTSBURGH and MIDLAND, PA.

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: ROLLS . . . STEEL AND SPECIAL ALLOY CASTINGS . . . COMPLETELY INTEGRATED STRIP MILLS . . . HEAVY DUTY ENGINE LATHES . . . MACKINTOSH-HEMPHILL ROTARY STRAIGHTENERS . . . IMPROVED JOHNSTON PATENTED CORRUGATED CINDER POTS AND SLAG-HANDLING EQUIPMENT . . . SHAPE STRAIGHTENERS . . . END-THRUST BEARINGS . . . SHEARS . . . LEVELLERS

Peter V. Martin, sales manager of the metallurgical department, engineering and construction division of Koppers Co., Inc., since 1947, has been made an assistant vice president in the Freyn Engineering Department of that division. Mr. Martin will continue to have his headquarters in Pittsburgh, Pa.

Harry L. Brindle was appointed assistant to vice president-manufacturing, United States Steel Co., Pittsburgh, Pa. Mr. Brindle, who has been general

HARRY L. BRINDLE

superintendent of Edgar Thomson Works, Braddock, Pa., is succeeded by **James W. Kinnear, Jr.,** an operating executive with 28 years' experience in the steel industry. In 1947, Mr. Kinnear left U. S. Steel Co. to become president of Firth Sterling Steel and Carbide Corp. and returned to the staff of the vice president-manufacturing at U. S. Steel in February, 1951.

JAMES W. KINNEAR, JR.

Joseph K. Seyler was appointed superintendent of the Hazelwood cold finishing department at the Pittsburgh, Pa., works of Jones & Laughlin Steel Corp. Mr. Seyler had been serving as assistant superintendent of that department. **George L. Winslow** has been appointed assistant superintendent, cold finishing department, in charge of the South Side cold finishing department of the Pittsburgh works. Mr. Winslow had been serving as assistant superintendent, cold finishing department in charge of the Hazelwood cold finishing department, Pittsburgh works.

WHAT'S THE BEST WAY TO STRIP PAINT FROM METAL PARTS TOO LARGE TO BE SOAKED IN TANKS?

See Page 3

Oakite's New FREE Booklet on Paint Stripping

answers many questions that will lead you to better stripping procedures. You'll want to read more about:

What's the best way to strip large areas of structural metal where a steam supply is available? *See page 5.*

What is the best method when steam is not available? *See page 7.*

What is the cheapest way to strip metal parts in large volume? *See page 9.*

What are the best ways to prepare stripped surfaces for repainting? *See page 11.*

What strippers are best for removing oil-base paints? . . . Synthetic enamels, alkali-resistant plastics or resin-based paints? . . . Japans, wrinkle finishes, nitrocellulose lacquers, alkyds, phenolics and ureas? *See page 12.*

FREE For a copy of "How to STRIP PAINT" write to Oakite Products, Inc., 38H Thames St., New York 6, N. Y.

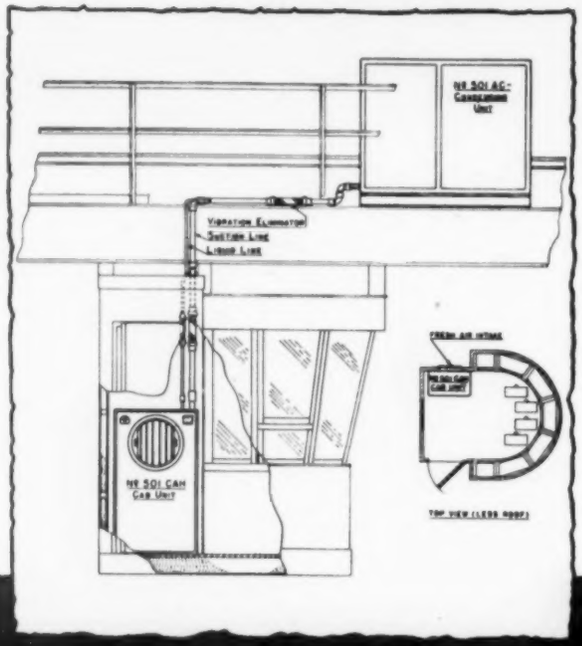
Machine cleaning	Tank cleaning
Electrocleaning	Pickling
Pre-paint treatment	Burnishing
Steam-gun cleaning	Rust prevention

SPECIALIZED INDUSTRIAL CLEANING

OAKITE

MATERIALS • METHODS • SERVICE

Technical Service Representatives in Principal Cities of U. S. & Canada



The Original Split System Cab Conditioner

This is the original split system now in use for over four years. Its operating efficiency has been unequalled. Throughout this period the Lintern split system has demonstrated its greater cooling efficiency, lower maintenance, and trouble-free operation. All of the many installations throughout the country have given universal satisfaction.

In the Lintern split system Aire-Rectifier the condenser is located at any convenient place on crane, and evaporator (cooling coil) is placed in cab. The two units are connected with refrigerant lines properly secured and protected against breakage. Condensers are air-cooled, assuring trouble-free service with but little maintenance.

Requiring but little space, the condenser and cab units are easy to locate, respectively on crane and in cab so that they do not interfere with operations in any way.

These Aire-Rectifiers hold properly insulated cabs at a cool 85° F. and relative humidity of 30% to 50% at ambient temperatures of 170° without excessive head pressures or wear on the machine.

May we send you complete information on the Lintern split system Aire-Rectifier (patents pending) and its application to your particular needs?

THE LINTERN CORPORATION

29-2 RIVERSIDE DRIVE • BEREA, OHIO

John T. McCarley has been promoted to assistant general manager, and **Kenneth H. Bergstrom** succeeds him as manager of production at the Philadelphia division of Yale and Towne Manufacturing Co.

L. L. Garber, vice president, H. K. Porter Co., Inc., has been appointed general manager of the company's Hinderliter Tool Co. division, Tulsa, Okla. Mr. Garber has been succeeded as general manager of American-Fort Pitt Spring division by **H. A. Harrington,** former works manager.

Bernard R. Queneau has been appointed chief metallurgist and **Frank O. Phillips,** superintendent,

BERNARD R. QUENEAU

maintenance division at U. S. Steel Co.'s Duquesne, Pa., works. Dr. Queneau had been chief development

FRANK O. PHILLIPS

metallurgist at the South works, Chicago, Ill. Mr. Phillips had been serving as superintendent, 45 in. mill at Homestead, Pa., works.

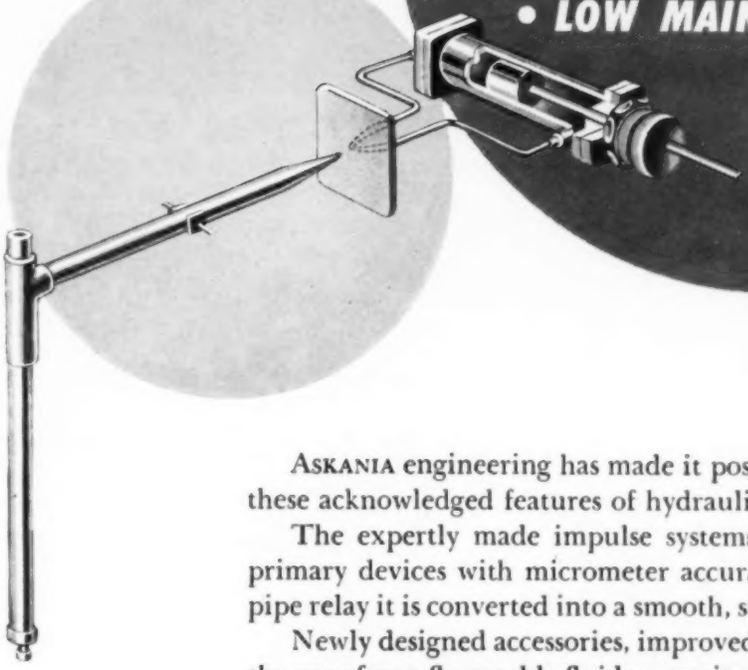
Frank J. Burd, was honored August 22 in Milwaukee, Wisc., at a luncheon given by G. S. Crane, president, Cutler-Hammer, Inc., and other company officials. The luncheon held at the Milwaukee Club was in tribute to Mr. Burd's 50-year record with the large electrical manufacturing firm.

Dorsey H. Rowe was appointed advertising manager of Cleveland Worm and Gear Co. and its affiliate,

ASKANIA HYDRAULIC CONTROLS

Features

- ACCURATE MEASURING DEVICES
- POSITIVE ACTION
- SAFE OPERATION
- LOW MAINTENANCE



ASKANIA engineering has made it possible for Industry to appreciate these acknowledged features of hydraulic control.

The expertly made impulse systems measure the signal from the primary devices with micrometer accuracy. Through the exclusive jet pipe relay it is converted into a smooth, stepless, positive hydraulic force.

Newly designed accessories, improved fittings, and construction, plus the use of non-flammable fluids, permit use of Askania hydraulic control even in hazardous locations, corrosive or dirty atmospheres and low temperatures.

ASKANIA hydraulic controls have operated perfectly for years without maintenance or repair. The hydraulic fluid provides continuous lubrication and there are no minute clearances or delicate adjustments required for the jet pipe relay to function continuously.

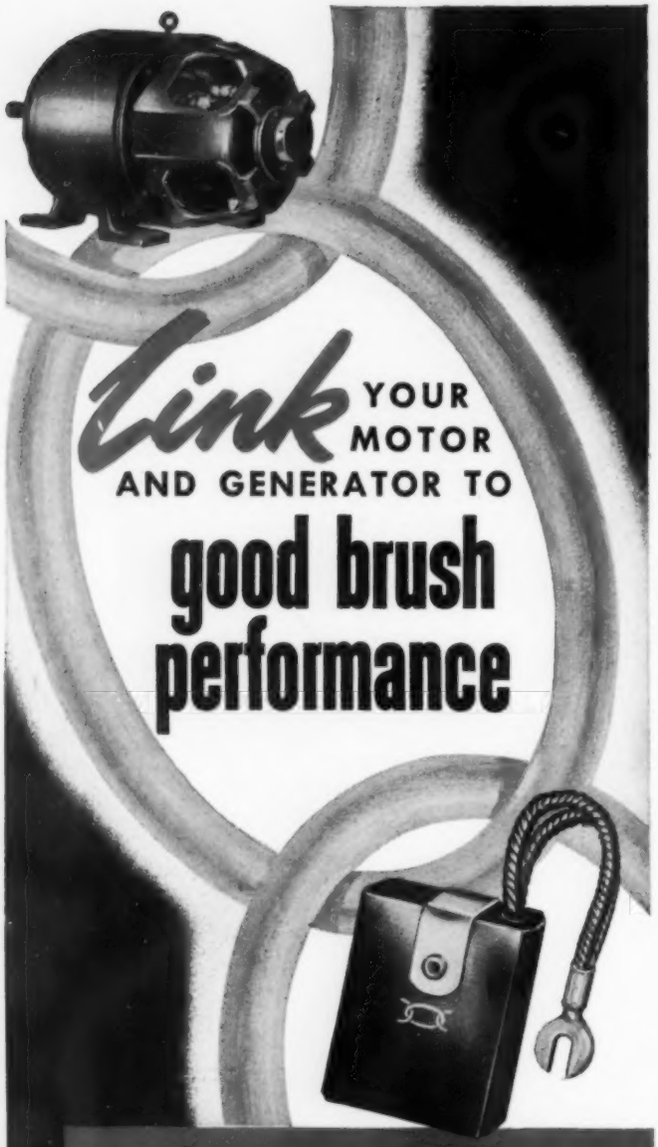
The simple operating principles of Askania hydraulic controls and their construction permit assembly after inspection, when necessary on the job, with a minimum of down time.

ASKANIA Controls

ASKANIA REGULATOR COMPANY

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

240 EAST ONTARIO STREET · CHICAGO 11, ILL.



MORGANITE
CARBON BRUSHES

Using Morganite Brushes is one sure way to better motor and generator performance. The Morganite *link control* method of manufacture guarantees proper design, highest quality materials and accurate workmanship. Morganite engineering service assures competent, practical collaboration on every brush problem.

Morganite INCORPORATED
LONG ISLAND CITY 1, NEW YORK

Manufacturers of Morganite Self-Lubricating Carbon Specialties including Seals, Rings, Valves, Slides, Bearings, etc., and Carbon Piles

Farval Corp., Cleveland, Ohio. Mr. Rowe comes to Cleveland Worm and Gear from the Penton Publishing Co., where he served for several years as associate editor of the "New Equipment Digest."

Dr. Raymond C. Machler was named director of research and a member of the executive committee of

DR. RAYMOND C. MACHLER

Leeds & Northrup Co., Philadelphia, Pa. Dr. Machler, who was formerly associate director of research, succeeds **I. Melville Stein,** who recently was elected to the newly created post of executive vice president.

Harold J. Thompson has joined the Chicago, Ill. agency for Electric Products Co. Associated with the Hooper-Green Co., Mr. Thompson is specializing in handling Electric Products' line.

Clifford M. Dunn has been appointed manager of General Electric Co.'s Michigan apparatus district. As

CLIFFORD M. DUNN

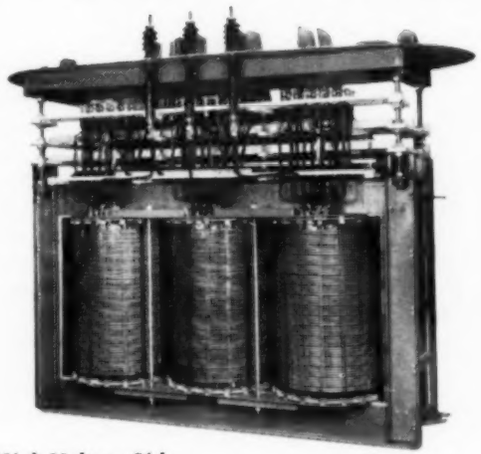
district manager, Mr. Dunn succeeds **Arthur R. Hines,** who has been appointed assistant manager of marketing for the company. Mr. Dunn's headquarters will be in Detroit, Mich.

Hendley Blackmon has been named manager of engineering association activities for the Westinghouse Electric Corp. He will work with Westinghouse engineers in the preparation of papers to be presented

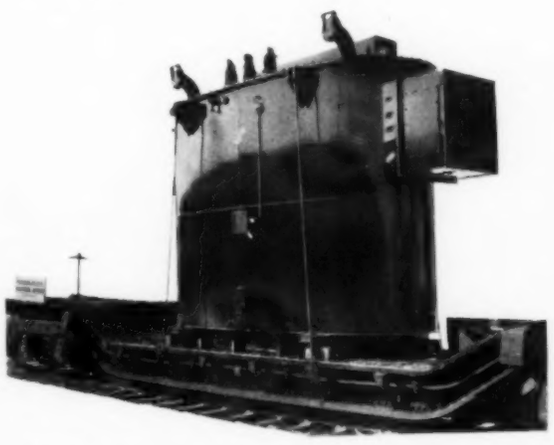
18,000 Kva Furnace Transformer, Three Phase, 60 Cycles, 55°C. Rise, Low Voltage Side

★ The transformer that supplies power to an electric furnace is an extremely complicated unit. The rules governing designs and construction of Power Transformers do not apply to Furnace Transformers. Many special conditions such as overloads, short circuit stresses, distribution of currents and reduction of eddy losses must be met by engineering skill and highly perfected workmanship.

Furnace Transformer FACTS



High Voltage Side



Completed Transformer ready for shipment

1 Overloads & Short Circuit Stresses

Electric Furnace operation inherently subjects Furnace Transformers to frequent short circuits and heavy overloads. The effect of this on the transformer is complicated by the wide range of voltages which necessitates cutting out large portions of the primary windings. The effects of both the radial and axial short circuit forces are greatly reduced in Pennsylvania Furnace Transformers by the use of Circular Coils and an ingenious winding arrangement.

2 Balancing of Stresses

Pennsylvania coils are balanced to reduce the radial and axial short circuit stresses to a minimum. **1.** The circular shape protects the coils against deformation due to radial short circuit forces. **2.** The total axial short circuit force is calculated for each design and the coils are subjected to an equivalent pressure in an hydraulic press. The ability of the coils to maintain their shape, under the prescribed pressure, guarantees that the transformer will safely withstand short circuits.

3 Distribution of Currents

Due to the heavy secondary currents, the winding must be subdivided into numerous parallel sections. A unique arrangement of the windings insures that each section carries an equal share of the current.

Careful transposition of the individual conductors of each section in the windings reduces the copper eddy losses to a minimum. This results in improved efficiency, more uniform copper temperature and prevention of hot spots.

Pennsylvania TRANSFORMERS

Furnace Transformer Experts

Pennsylvania TRANSFORMER COMPANY

CANONSBURG, PENNSYLVANIA

Greater Pittsburgh District

before engineering association meetings. Mr. Blackmon, who has served as assistant manager of the activity since 1949, succeeds **Frank Thornton, Jr.,** who recently retired.

V. H. Ferguson has been elected president of the newly formed Ferguson Equipment Corp. He resigned from the Loftus Engineering Corp. to direct this

V. H. FERGUSON

organization. The new corporation has established executive and engineering offices at 21st Street and Penn Avenue and has fully equipped shops at 20th Street and Liberty Avenue, Pittsburgh, Pa. Special attention will be given by the new firm to designing and building industrial heat treating furnaces and related equipment.

James MacGregor has been elected president of York Engineering & Construction Co., Pittsburgh, Pa. He was formerly a partner of the company, which was incorporated on July 1, 1951. Mr. MacGregor, with his brother, **Charles MacGregor,** founded the York Engineering & Construction Co. in 1948. Prior to that

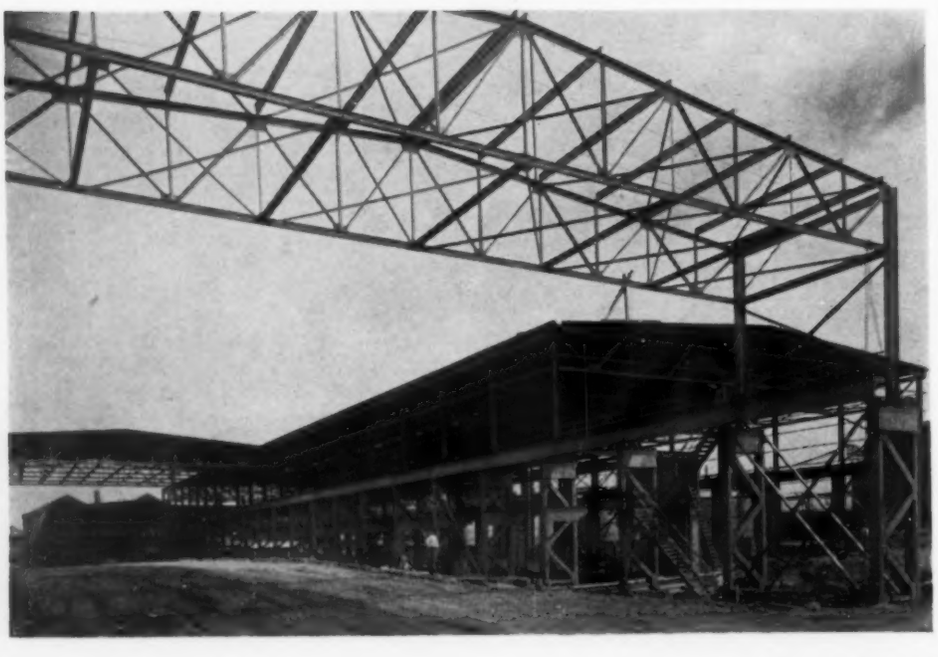
JAMES MacGREGOR

he worked for United States Steel Co. as a control engineer at Duquesne, Pa. works, and as an evaluation engineer in the corporation's tax department after the war. Prior to joining United States Steel Co., he was a design draftsman for Continental Foundry & Machine

AT THE NEW J&L ROD MILL IN ALIQUIPPA

YORK

- Designed and wrote specifications for all buildings and their foundations and for the motor room.
- Designed foundations for all mill equipment, built by United Engineering & Foundry Company, and for motor room equipment.



Jones & Laughlin Steel Corporation is one of the many satisfied York customers in the steel producing industry. York has facilities for a complete engineering and construction service for steel mills; including the design of buildings, foundations, and equipment, as well as project planning, coordination, and cost control. Write for information about our services.

YORK
ENGINEERING & CONSTRUCTION CO.
951 PENN AVENUE
PITTSBURGH 22, PA.

Here's How

to Erase Smoke Troubles

VIOLATION OF SMOKE ORDINANCE

LOSS OF FUEL ECONOMY

BAD COMMUNITY RELATIONS

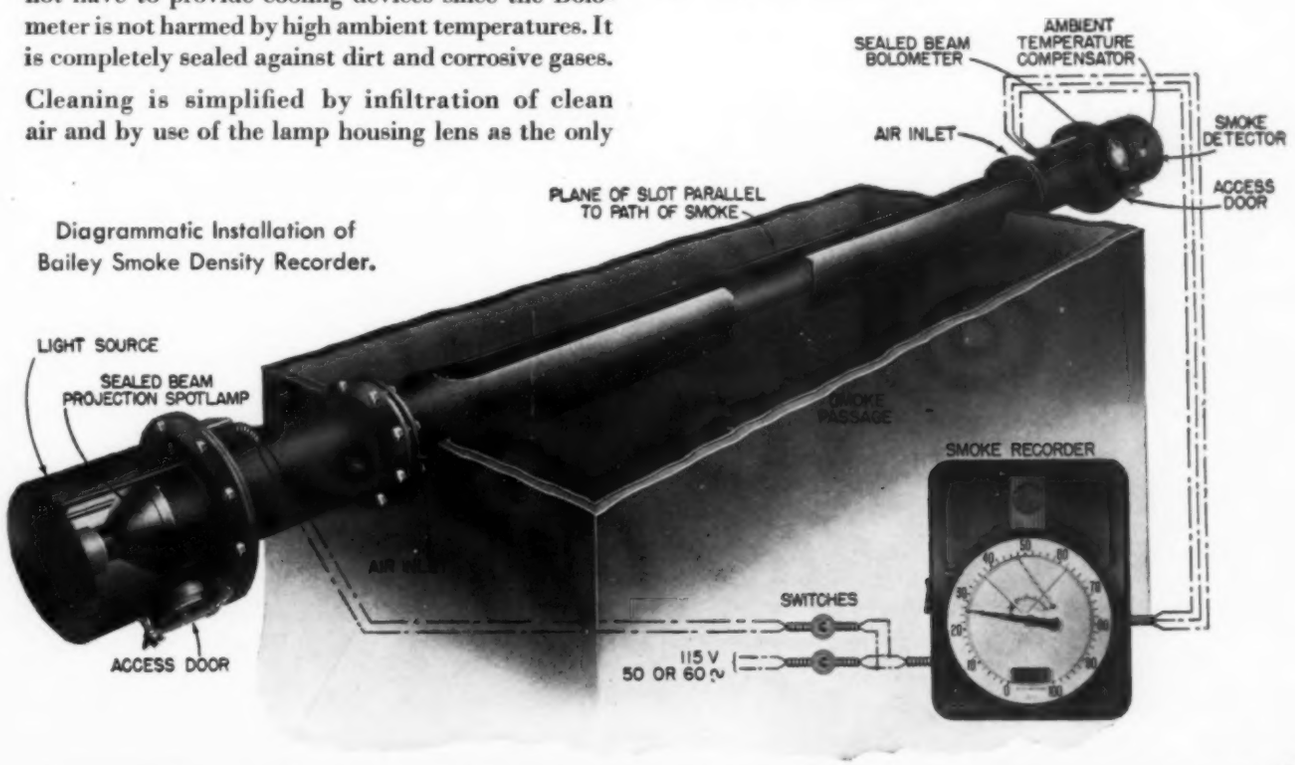
★ One of your first steps in erasing these troubles which result from excessive smoke, should be the installation of a Bailey Smoke Density Recorder. This 24-hour recorder is not an ordinary photo-cell instrument. Instead it detects smoke density by a Bolometer which is simply a sturdy tungsten filament and a parabolic mirror, mounted in a standard sealed beam automobile head lamp housing.

In using this simple, unique smoke detector, you do not have to provide cooling devices since the Bolometer is not harmed by high ambient temperatures. It is completely sealed against dirt and corrosive gases.

Cleaning is simplified by infiltration of clean air and by use of the lamp housing lens as the only window between the Bolometer and the gas passage.

It's easy to secure and maintain alignment of the sealed beam light source with the Bolometer since they are mounted at opposite ends of a slotted pipe which extends across the smoke passage.

For complete information on how you can profitably use this unique instrument to erase your smoke troubles, ask for Bulletin 211, "Bailey Smoke Density Recorder".



Diagrammatic Installation of Bailey Smoke Density Recorder.

G-29

BAILEY METER COMPANY

1047 IVANHOE ROAD, CLEVELAND 10, OHIO • BRANCH OFFICES IN PRINCIPAL CITIES

BAILEY METER COMPANY LIMITED, MONTREAL, CANADA

Let Bailey Smoke Density Recorders Watch Your Stacks

CRANE BUILDERS Since 1903

BEDFORD CRANES

Capacities 5 to 150 Tons

Designed and Engineered to Meet Your Requirements

Any Span or Lift
Send For Your
Copy Of Catalog

ELECTRIC OVERHEAD TRAVELING CRANES
GANTRY CRANES • STEEL DERRICKS
BUILT TO YOUR SPECIFICATIONS
STRUCTURAL STEEL • STEEL BUILDINGS

BEDFORD FOUNDRY & MACHINE CO.

Engineers
Designers
Fabricators

BEDFORD, INDIANA
U. S. A.

Gray Iron Castings

for custom-engineered POWER look to... EP

• Since 1909, our job has been to create and develop special electrical rotating equipment. This specialization assures equipment designed and built to your exact requirements... guarantees greater dependability, longer life, less maintenance.

Return coupon for information on our Custom-Engineered a-c and d-c motors and generators . . . induction motors . . . battery chargers . . . frequency changers.

Our nation-wide sales engineering and service organization stands ready to meet all User requirements.

THE ELECTRIC PRODUCTS CO.

Attach coupon to your letterhead for your copy of Bulletin 2-200.

1718 CLARKSTONE ROAD
CLEVELAND 12, OHIO

NAME_____
TITLE_____
COMPANY_____
STREET_____
CITY_____ ZONE_____ STATE_____

X-75

Co. from 1936 to 1940. Other recently elected officers of York are **Charles MacGregor,** vice president; **Philip M. Weber,** treasurer; and **J. Donald Cook,** secretary.

H. Stanley Bimpson has been named to the office of the director of engineering of Allis-Chalmers general machinery division as consulting engineer. Mr. Bimpson, a mechanical engineering graduate of the University of Virginia, has been with Allis-Chalmers since 1920. During this time he has served in various capacities in the engine and condenser and blower and condenser departments. Since 1947, he had been chief engineer of the company's blower and condenser department.

F. H. FREY

F. H. Frey was named manager of roll sales for Pittsburgh Rolls division of Blaw-Knox Co., and **P. C. Haldeman, Jr.,** was appointed general superintendent.

P. C. HALDEMAN, JR.

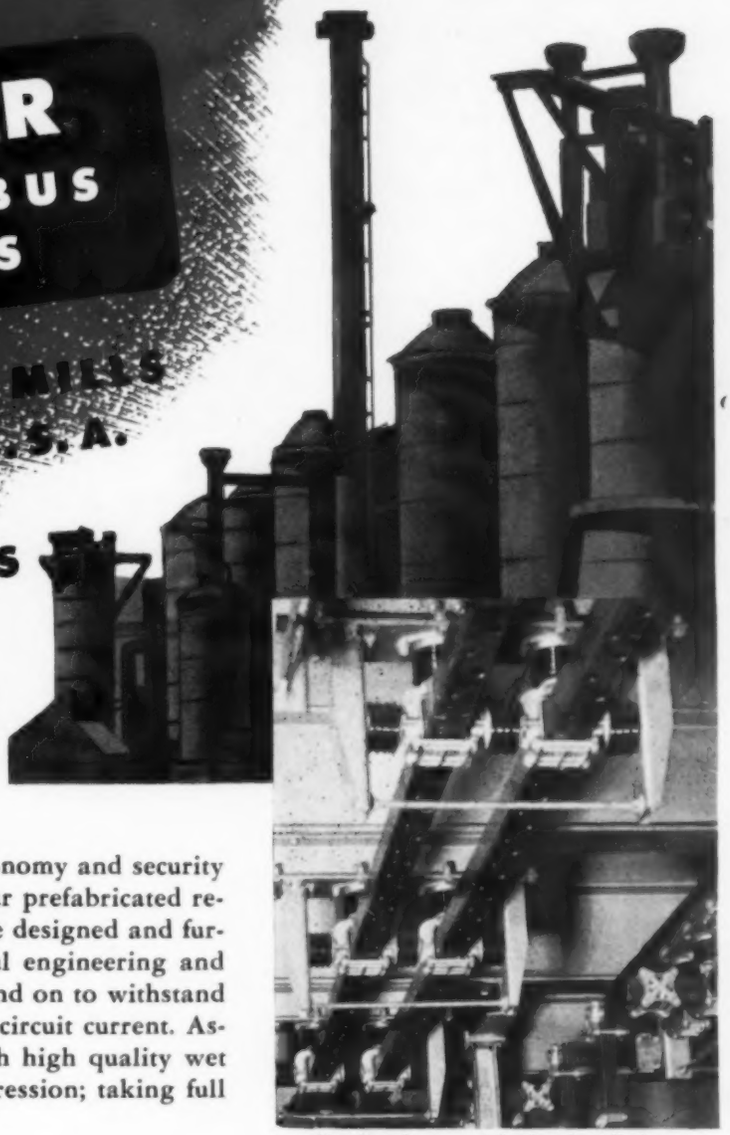
J. L. Singleton, vice president in charge of the general machinery division, and **R. S. Stevenson,** vice president in charge of the tractor division, were elected to the board of directors of the Allis-Chalmers Manufacturing Co. They succeed as directors the late **Walter Geist** and **W. C. Johnson.**

Cecil Harvey, formerly assistant to sales manager of Gibson Electric Co., has recently joined the headquarters sales staff of the large motor division of Elliott Co. at Ridgway, Pa.

DELTA-STAR REINFORCED BUS STRUCTURES

ARE INSTALLED IN MILLS THROUGHOUT THE U.S.A. AND IN MANY FOREIGN COUNTRIES

FOR GREATEST SAFETY in Event of Short-Circuit



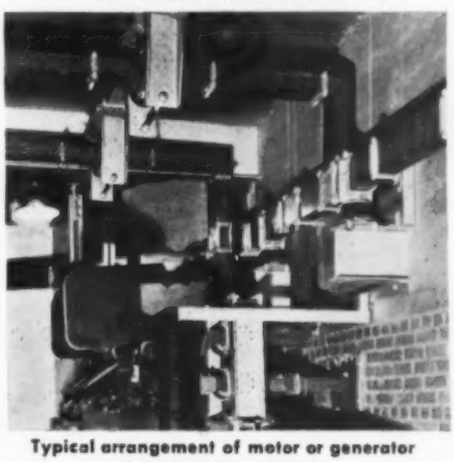
Leading steel mills have recognized the economy and security which is inherent when installing Delta-Star prefabricated reinforced bus structures. These structures are designed and furnished complete to the last detail. Careful engineering and fabrication assure a structure you can depend on to withstand the destructive forces resulting from short circuit current. Assemblies consist of heavy steel frames with high quality wet process porcelain insulators used in compression; taking full advantage of their greatest strength.

Our engineers will be glad to discuss your bus problems and work out a layout to suit your special requirements. Prefabricated open or enclosed bus structures are available for aluminum or copper bars and tubing; structural and special shapes; indoor or outdoor service.

OTHER DELTA-STAR PRODUCTS
Used in Mills and Industrial Plants

- Crane Rail Supports
- Disconnecting Switches
- Terminators (Potheads)
- Plugs and Receptacles
- Spool Insulator Cable Supports
- Water Cooled Conductors and Fittings
- Interrupter Switches
- Power Connectors

Ventilated square tube bus installation in a midwestern steel mill.



Typical arrangement of motor or generator circuit-breaker sections.

DELTA-STAR ELECTRIC COMPANY

DIVISION OF H. K. PORTER COMPANY, INC.

2437 Fulton Street • Chicago 12, Illinois

DISTRICT OFFICES IN PRINCIPAL CITIES

Delivered WHEN you want them
... and in the BEST quality*

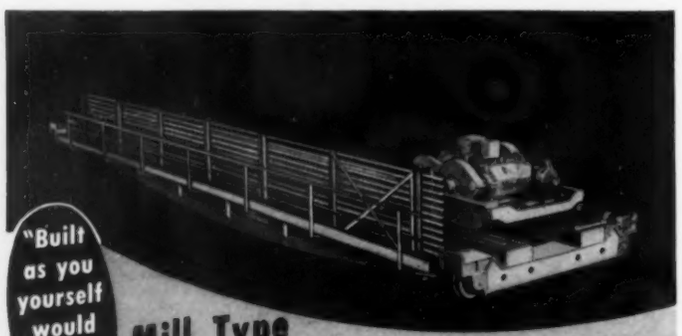
COPPER

Valve Seats
Valve Gates
Inwall Plates
Bosh Plates
Tuyeres
Coolers
Monkeys
Copper and Bronze Castings

Telephone Collect 3-4186
FALCON BRONZE CO.
YOUNGSTOWN 3, OHIO
Established 1890 - Incorporated 1893

LICENSED MAKERS OF ALL PATENTED DESIGNS

*DEPENDABLE FOR 61 YEARS, SINCE 1890



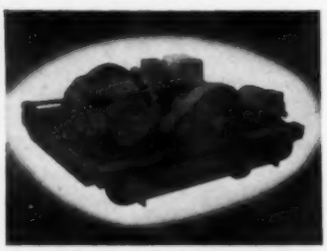
"Built as you yourself would build them"

Mill Type Cranes BUILT BY *Browning*

HAVE *Strength* WHEREVER STRENGTH IS NEEDED

Satisfying A.I.S.E. specifications, Browning Mill Type Cranes incorporate types of motors and controls on which you have standardized. This flexibility suits your VRB crane *perfectly* to your needs. Our design, springing from 49 years' experience, places plenty of strength where it is required.

Ask for our Bulletin "E"



Husky 10-ton mill type trolley equipped with separate load girt for easy removal.

VRB
VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

Reliance Electric & Engineering Co., Cleveland, Ohio, has added four sales application engineers, as follows: **Ralph D. Abercrombie, Jr.,** goes to Reliance's sales office in Buffalo, N. Y. **Rex T. Willard** has been assigned to the company's sales office in Atlanta, Ga. **Merle Kip Sieber** goes to Reliance's New York sales office, **Nicholas D. McKay** has been assigned to the company's Detroit, Mich., office. Named to handle a temporary special assignment in a sales analysis capacity at Reliance's Newark, N. J., office, is **John H. Stevens.** The two field service engineers appointed by Reliance are **Cecil D. Wright,** attached to the company's Charlotte, N. C., office, and **Charles F. Carnish,** who goes to the Detroit, Mich., office.

George Breza has been appointed chief engineer of Mackintosh-Hemphill Co., Pittsburgh, Pa. Mr. Breza had been assistant chief engineer since 1937 when he joined the company. His former employment was with Amsler-Morton Co. where he had been engaged in the design of furnaces and machinery.

Ressler A. Dusseau was named assistant general manager of the Automatic Transportation Co., Chicago,

RESSLER A. DUSSEAU

Ill. Mr. Dusseau, until now chief engineer of rider-type automatic electric trucks, assumes the responsibilities formerly held by **Theodore Smith,** who has resigned.

V. de P. Gerbereux has been appointed manager of the centrifugal pump sales division of Worthington Pump and Machinery Corp. He succeeds **A. H. Borchardt** who was recently elected vice president in charge of centrifugal, reciprocating and vertical turbine pump sales.

Carl J. Gross was named general manager of a newly established midwestern department of Federated Metals division of American Smelting and Refining Co. The midwestern department comprises the states of North and South Dakota, Minnesota, Michigan, Wisconsin, Indiana, and parts of Illinois, Ohio, Iowa, and Kentucky. Federated has two producing plants in this territory at Whiting, Ind. and Detroit, Mich. Both will be under the direction of Mr. Gross who will continue as manager of the Whiting plant. **Allan Nichamin,** formerly Detroit sales manager, has been appointed manager of the Detroit plant to succeed **Robert Ruch,** resigned. **Waldo C. Larson** continues as superintendent

Homestead-Reiser
Self-Seald
LUBRICATED PLUG VALVES

The *Full-Port-Area* Valve built to outlast all other lubricated plug valves in the 200 pound working pressure class.

- **100% PORT AREA**
- **100% LUBRICANT SEAL AROUND PORTS**
- **SELF-SEALING**
- **AUTOMATIC ADJUSTMENT FOR WEAR**
- **EXTREME ECONOMY OF LUBRICANT**

Remains drop-tight for
Up to 22 TIMES
more operations
without Re-lubrication

Write today for Reference Book 39-Section 5.

Self-seald MEANS

. . . that in addition to a full-port lubricant seal, the wedge action of the plug under line pressure, forces the surfaces of the plug outward, and constantly presses against the seating surfaces of the body, keeping them always in intimate contact. The plug automatically adjusts itself for wear, assuring extra long life, maximum leakless service, and lubricant economy.

HOMESTEAD VALVE MANUFACTURING COMPANY

Serving since 1892

P. O. BOX 21 CORAOPOLIS, PA.

Hyde Park

STEEL MILL EQUIPMENT

Roll Turning Lathes — Roll Tables
Mill Stands — Stretcher Levellers
Sheet Pack Carriers — Mill Shears
Surface Plates — Floor Plates
Mill Reduction Drives

RED CIRCLE Rolls ALLOY–CHILLED

CHILLED and ALLOY IRON ROLLS

GRAY IRON CASTINGS

Inquiries invited

HYDE PARK FOUNDRY & MACHINE CO.

HYDE PARK, PA. (PITTSBURGH DISTRICT)

INCREASE TONNAGE PICKLED WITH
HEIL STEAM JET AGITATORS

Heil E-4 Steam Jet Agitator for Sheet or Batch Pickler

- REDUCED PICKLING COSTS with increased production.
- LONGER LIFE assured with Rugged Construction. Withstands Thermal Shock Higher Temperatures and Acid Concentration.

HEATING AND AGITATION IN ONE OPERATION

Write Today for Information on the Best Design for your Operation.

HEIL PROCESS EQUIPMENT CORP.
12901 Elmwood Avenue, CLEVELAND 11, OHIO
Sales Representatives in all Principal Cities

at Detroit, Mich. **John W. Kelin** has been appointed midwestern sales manager. **George M. Baumann** has been appointed assistant general manager and purchasing agent of the midwestern department.

A. O. Seehafer has been placed in charge of a newly opened Chicago, Ill., office of Electric Products Co. The new office will be devoted exclusively to the sale and servicing of battery charging equipment for industrial trucks.

Obituaries

Edward L. Zapp, chief metallurgist, Tube Reducing Corp., Wallington, N. J. died on August 5. Prior to joining Tube Reducing Corp., Mr. Zapp had been with Henry Disston & Sons, Inc. and with Hyatt Roller Bearing Corp.

William C. Johnson, 49, executive vice president of Allis-Chalmers Manufacturing Co., Milwaukee, Wisc., died July 26. Mr. Johnson was a member of the firm's board of directors and also a member of the executive committee of the board. In addition, Mr. Johnson served as chairman of the board of Canadian Allis-Chalmers, Ltd.

William A. Coryea, 58, a project manager of Rust Engineering Co., died August 13.

I Wish . . .

to enter one year's subscription for the IRON AND STEEL ENGINEER at $7.50 per year:

☐ Check enclosed
☐ Bill me later

I desire information on membership in the Association of Iron and Steel Engineers:

☐ Application blank
☐ Data

Name_____

Title_____

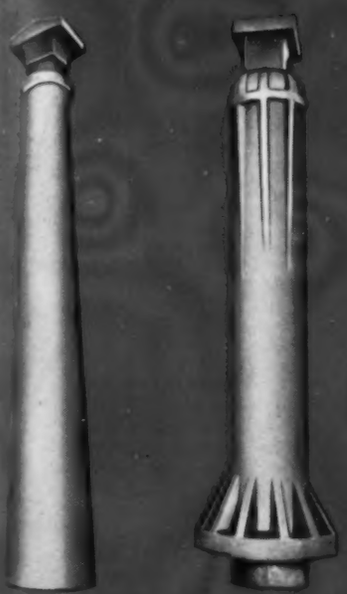
Company_____

Mailing Address_____

Mail this coupon to:

Association of Iron and Steel Engineers
1010 Empire Building
Pittsburgh 22, Penna.

..ALL MUSCLE!



Unusual stresses, strains, shock, abrasion, fatigue, are all thoroughly studied before Union makes a mold or pours a heat. The careful consideration of these important factors plus the high-strength steel that goes into Union Steel Castings insure the very best in performance.

They're "all muscle"!

"UNION" MAKES

GEARS & PINIONS • TONGS & TONG LEVERS • UNIVERSAL COUPLINGS & SPINDLES
CHARGING BOXES • PEELS • SLAG POTS • INGOT CARS & CHARGING BOX CARS
SPECIAL UNIVAN & ARMOR • STEEL CASTINGS

UNION STEEL CASTINGS

DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH, PA.

TRADE LESLIE MARK

SELF-CLEANING STRAINERS

Complete *protection* for Reducing Valves, Pump Governors, Temperature Regulators, Turbines, Pumps, Traps, Valves and other equipment against dirt, rust and scale is provided at lower cost by LESLIE Self-Cleaning Strainers.

Protection from foreign matter increases the life of the equipment and prevents costly down-time. Self-Cleaning feature allows cleaning of screen without removal from strainer body or shutting off operating fluid.

Available in sizes (1¼"-10"), in cast iron, cast bronze, cast steel, carbon moly, chrome moly and stainless steel, with screwed, flanged or socket welding connections, to 1500 lbs. press., 1000°F.

ESTABLISHED 1900 LESLIE CO.

Stocked and sold by Industrial Distributors.

SEND FOR—Bulletin No. 465

247 Grant Avenue Lyndhurst, New Jersey

1158

PRESSURE REDUCING VALVES • PRESSURE CONTROLLERS
FLOATLESS LEVEL CONTROLS • PUMP GOVERNORS
TEMPERATURE REGULATORS • SELF CLEANING STRAINERS
AIR HORNS • STEAM WHISTLES

GENERATION of SERVICE

RUGGED & DEPENDABLE

MAGOR AIR DUMP CARS

Built for Steel Plant Service, Magor Air Dump Cars will operate at maximum efficiency for as long as 30 years.

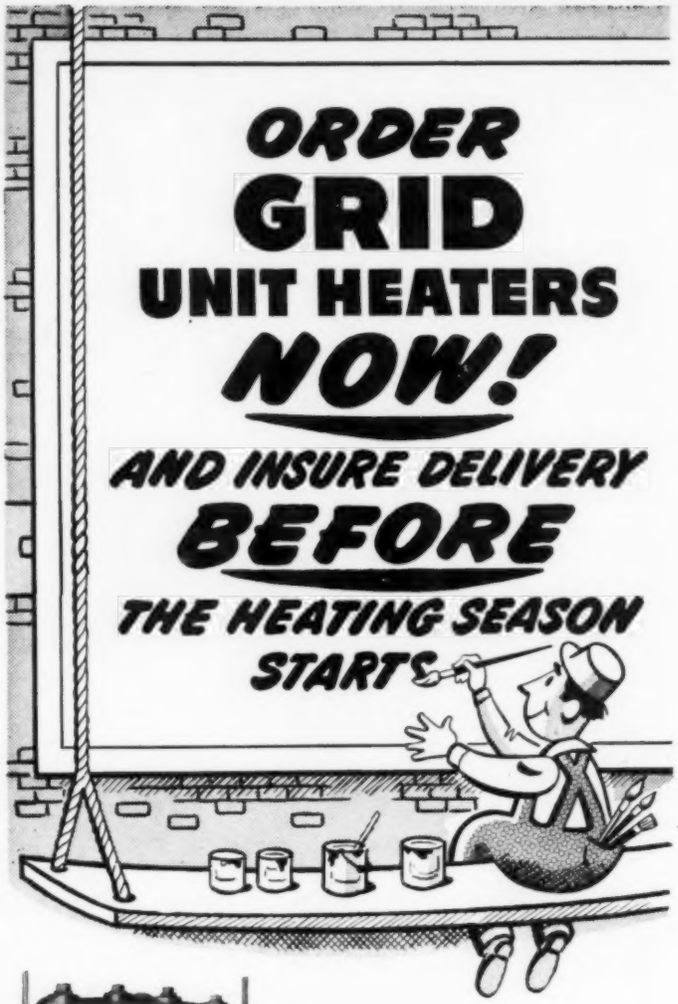
Maintenance costs are less — almost 50% less than gondola, hopper or outmoded air dump cars. Every feature of Magor Air Dump Cars is designed to stand up under the tremendous strain of continuous operation.

Magor Air Dump Cars can cut your refuse disposal costs as much as 40%.

Write for Bulletin DS-102.

MAGOR CAR CORPORATION, 50 CHURCH ST., NEW YORK, N. Y.

World's Largest Producer of Air Dump Cars



THE UNIT HEATER WITH HIGH TEST CAST IRON HEATING SECTIONS . . . FREE OF ELECTROLYSIS

Double your money's worth—if you order GRID Unit Heaters NOW—in advance of the regular heating season, because our inventory on GRID Unit Heaters is the best in years. And, GRID Unit Heaters are the best heating buy from the standpoint of maintenance-free service and low cost of operation. There is no waiting for delivery on GRID Unit Heaters and there is no maintenance after you get them, because . . .

GRID cast iron construction withstands corrosive fumes.

GRID wide fin spacing facilitates easy cleaning.

GRID will withstand steam pressures up to 250 lbs., and is free of electrolysis.

GRID fins are cast integral with the steam chamber assuring even distribution of heat. It's not possible for GRID fins to come loose from the steam chamber to cause loss of heating efficiency.

GRID design incorporating proper fan sizes, motor speeds and outlet temperatures results in a properly balanced heating unit, especially when high steam pressures are used.

Consult our Engineering Department and Sales representatives for advice on heating problems, including Unit Heaters, Blast Coils and Radiation. Send for complete catalog . . . no cost . . . no obligation.

D. J. MURRAY MANUFACTURING CO.

Manufacturers Since 1883

WAUSAU • WISCONSIN

Whatever your steel production problems,

HAGAN Air Operated Soaking Pit Controls are

- ★ faster
- ★ easy to adjust
- ★ easy to maintain, and
- ★ sensitive at all flow rates

HAGAN Air Operated Soaking Pit Controls help

- ★ prevent overheating
- ★ prevent washing of ingots
- ★ provide longer refractory life

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION
Hagan Building
Pittsburgh 30, Pa.

HAGAN CORPORATION

METALLURGICAL FURNACE CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
BOILER COMBUSTION CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

Roll More Tons per pass with PARALLOY

REGISTERED TRADE-MARK

The Quality Name in

PINCH ROLLS
COILER ROLLS
TENSION ROLLS
STEEL MILL ROLLS

No Scratching or Galling

500-600-BRINELL

Also Makers of

DUCTILE IRON

... A Recent and Revolutionary development in the casting industry.

Other Y&M Products

- HYDRAULIC SLAB AND BILLET PILERS
- STRIP AND SHEET OILING EQUIPMENT
- SHEET SCRUBBER AND CLEANING LINES
- HOT SAWS—ROCKING AND SLIDE TYPES
- HOT BEDS—COOLING BEDS—TRANSFERS
- BILLET EJECTORS—PINCH ROLL STANDS
- SLITTERS—SPECIAL SHEARS AND GAUGES
- TILTING TABLES—TRAVELING AND LIFTING TABLES
- CONTINUOUS PICKLING LINES—ROLLER LEVELLERS
- FURNACE CHARGING EQUIPMENT—FURNACE PUSHERS
- STRIP STEEL COILERS AND REELS—SCRAP BALLERS
- RAILROAD SPIKE FORMING MACHINES—ROLL LATHES
- SHEET GALVANIZING LINES WIRE PATENTING FRAMES
- STRETCHER LEVELLERS—ANGLE AND SHAPE STRAIGHTENERS
- ROLLING MILL TABLES—GEAR AND INDIVIDUAL MOTOR TYPES
- MACHINERY BUILT TO CUSTOMER'S DESIGN AND DETAIL DRAWINGS

The Youngstown Foundry & Machine Co.

OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY

Youngstown, Ohio

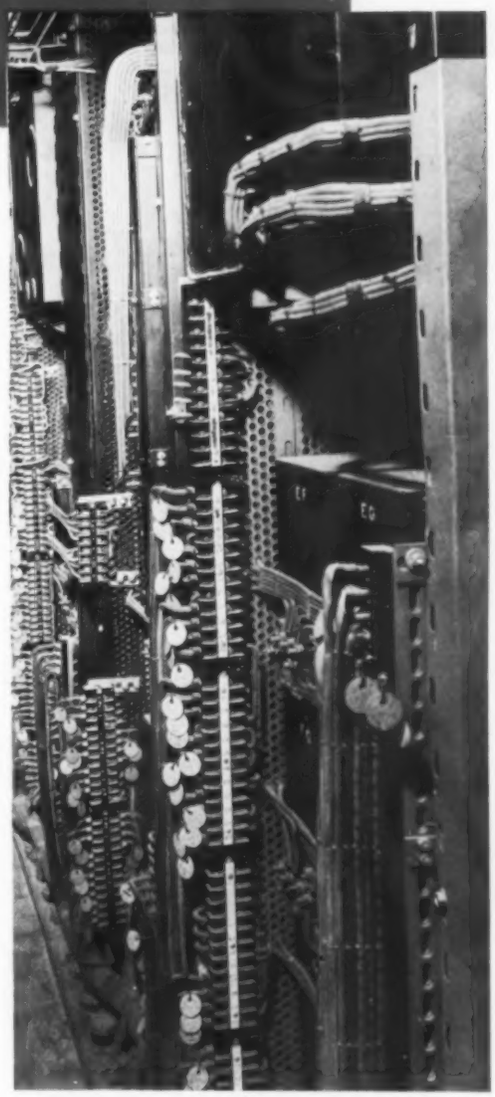
FOR "ROUND-THE-CLOCK" CIRCUIT SECURITY—

Multi-conductor control cables have color-coded Okoprene over each conductor with an Okoprene sheath over-all.

Okolite-Okoprene cables can be furnished with interlocked bronze armor where troughs or trays are used.

For wet underground runs, lead-sheathed Okolite-Okoprene cables provide extra security (note rubber fillers).

OKOLITE-OKOPRENE® CONTROL CABLES



Control cable must be the most versatile of all types of cable. In its wide variety of uses, control cable may be called upon to operate under almost any kind of service condition.

Horizontal or vertical, indoors or out, above or underground, in wet, dry, hot or cold locations, exposed to oils, acids, chemicals, sunlight or any kind of weather—control cables must keep key circuits operating *around the clock.*

Okolite-Okoprene is one type of cable construction that fulfills every requirement for control cable. The principal reason for its usefulness as control cable is the unique combination of Okolite Insulation and Okoprene Sheath. These two combine the highest dielectric strength with the most impervious protective covering... resulting in an unequalled soundness both electrically and physically.

Yet there are many other features which contribute to Okolite-Okoprene's outstanding performance as control cable. *Bulletin IS -1056* gives full details and specifications, with a description of Okonite's famous strip insulating process, special Okoloy conductor coating, a-c and d-c super-voltage testing, and many more.

If your expanding electrical plans call for additional control circuits, make sure you use the one cable qualified to give you "round-the-clock" security: Okolite-Okoprene. Inquire today from The Okonite Company, Passaic, N. J.

OKONITE SINCE 1878 *insulated wires and cables*

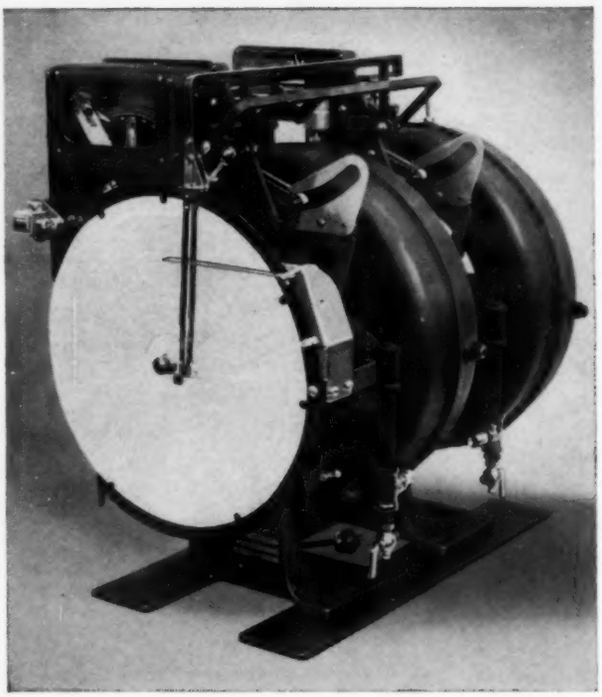
THE BEST CABLE IS YOUR BEST POLICY

9436

Full scale operation

from a differential of

one inch of water



Hagan Ring Balance Dual Meter, with two low differential rings.

In Hagan Ring Balance Meters the torque resulting from a given differential can be made high by using a ring with large cross-sectional area. Friction is low because of the knife-edge bearing on which the ring is mounted. The high torque-to-friction ratio thus obtained permits full scale operation with a differential as low as *one inch* of water.

Other Hagan Ring Balance Meters—all standard models—are available for maximum differentials up to 420 inches water column. In the 20 to 140-inch differential range, standard meters can be supplied for static pressures up to 15,000 psig.

Every Hagan Ring Balance Meter has these four major features:

1. No stuffing boxes
2. Mercury level is not critical
3. Dead weight calibration
4. Adjustable over a 7 to 1 range of differentials

Few meters have *any* of these features; only Hagan Ring Balance has them all.

For more information about these versatile meters just fill in the coupon and mail it to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

with HAGAN RING BALANCE METERS

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

Hagan Corporation
Hagan Building
Pittsburgh 30, Pennsylvania

Please send me further information on Hagan Ring Balance Meters. I am particularly interested in .....

NAME .....

POSITION .....

COMPANY .....

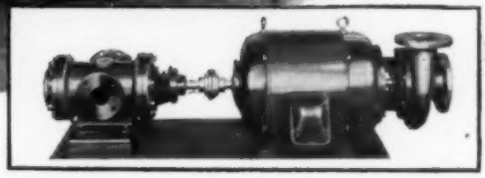
STREET AND NUMBER .....

CITY ..... ZONE ..... STATE .....

IS-9

De Laval products at work!

Keeping 192,000 H.P. well oiled and cooled...



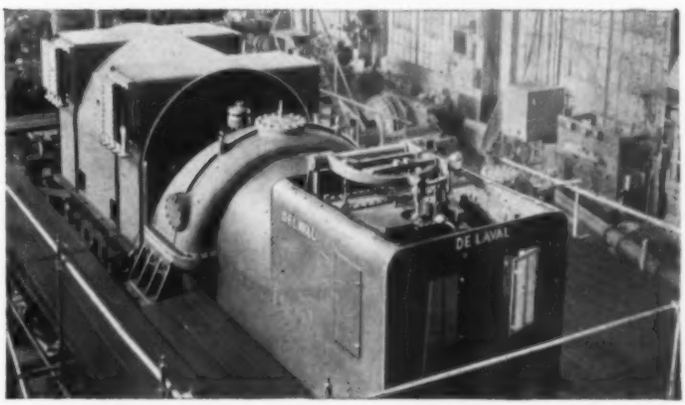
120 of these De Laval combined IMO rotary and centrifugal pump sets handle all the lube oil and jacket cooling water for 120-1600 hp radial gas engines in one of America's largest aluminum ore reduction plants.

The IMO is a versatile rotary pump that has dozens of applications around a power plant. You'll find them in high and low pressure fuel oil burner sets, pumping fuel oil to burners, unloading and transferring fuel and diesel oil, handling oil for lighting off and stand by service, providing pressure lubrication on pumps and turbines . . . We could fill the page with different applications but would rather send you a copy of our *Bulletin LG*. It shows the complete line of IMO's for capacities to 1000 gpm at pressures to 500 psi and 150 gpm at pressures to 1500 psi. *Write for your copy today.*

Meet the Grandaddy of all Turbines...

The first turbine-driven generating set to produce current on a commercial scale in the United States was this De Laval unit installed at the Chicago World's Fair in 1893. Grandad was a fast man in his day too . . . he delivered 10 hp at 24,000 rpm. Just four years later, four De Laval 100 hp turbine generators operating at 2840 psi, 750° F and two 50 hp turbines operating at 1420 psi supplied all the power for the Stockholm Exhibition. That is high pressure, high temperature operation even by todays' standards!

Next time you're in our neighborhood stop in and see Grandad. He is on display in our reception room. Then let us take you through our shops . . . there you'll see how the finest turbines in the country are built.



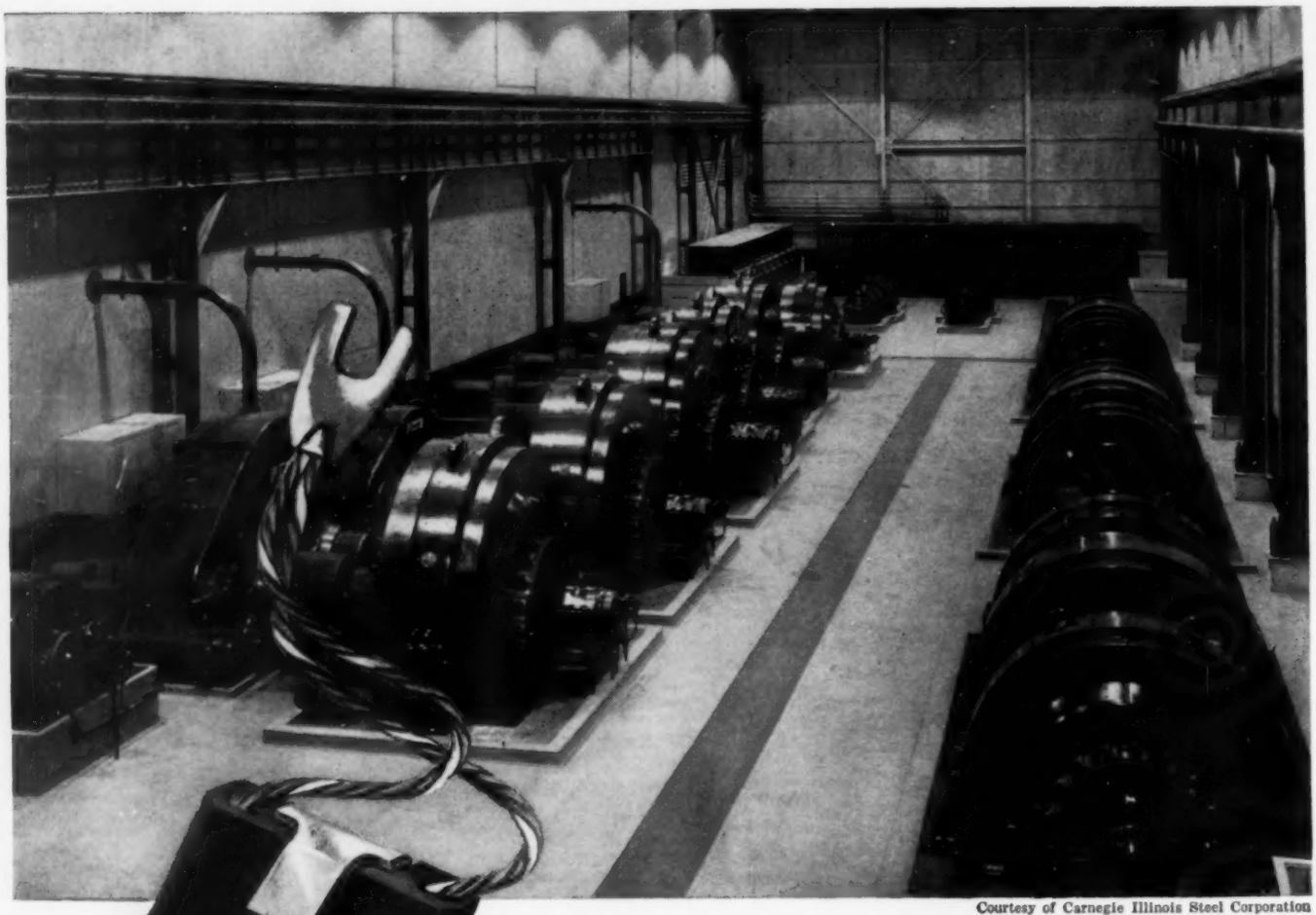
On Test - 11,500 KW

This big De Laval turbine generator and another just like it will soon go into service supplying power for one of our key Naval Bases. De Laval Turbine-Generators, *(we build them from 25 to 11,500 KW)* are at work in industrial, central station and municipal power plants all over the country. *Ask for a copy of our new Bulletin 4200.* Let it convince you that you should call in a De Laval engineer on your next turbine-generator job.

DE LAVAL STEAM TURBINE CO., TRENTON 2, N. J.

TURBINES • HELICAL GEARS • CENTRIFUGAL BLOWERS AND COMPRESSORS
CENTRIFUGAL PUMPS • WORM GEAR SPEED REDUCERS • IMO OIL PUMPS

50th DE LAVAL Anniversary



Courtesy of Carnegie Illinois Steel Corporation

KEEP PRODUCTION ROLLING WITH SA 35!

The NATIONAL standardized brush for main-drive motors

TRADE-MARK

Main-drive motors and generators are the most important machines in the mill. If one of them fails, production stops dead. Tons of steel may be held up. It doesn't pay to take chances with the brushes on this vital equipment.

Here's why "National" SA-Series grades lead the field on main-drive equipment:

- Complete dependability, proved in service for many years
- Closely controlled commutation factor
- Minimum commutator wear
- Long life
- Low flat price, for one box or 10,000 boxes
- Unequalled uniformity

STANDARDIZED BRUSHES FOR MAIN-DRIVE MOTORS AND GENERATORS

NC NUMBER	SPECIFICATIONS	APPLICATIONS
NC 12-5610	2½ x 1¾ x ⅜ Grade SA-35	For Westinghouse Tandem Holders
NC 16-5603	2½ x 1¾ x ½ Grade SA-35	For Westinghouse Tandem Holders
NC 12-4802	2¼ x 1½ x ⅜ Grade SA-35	For "Toe-to-Toe" Holders
NC 16-4804	2¼ x 1½ x ½ Grade SA-35	For "Toe-to-Toe" Holders

Order by NC Number

FOR COMPLETE INFORMATION on National Carbon's brush standardization program and the advantages it offers, write to National Carbon Company, A Division of Union Carbide and Carbon Corporation, Dept. IS.

The term "National" and the Three Pyramids Device are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N.Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

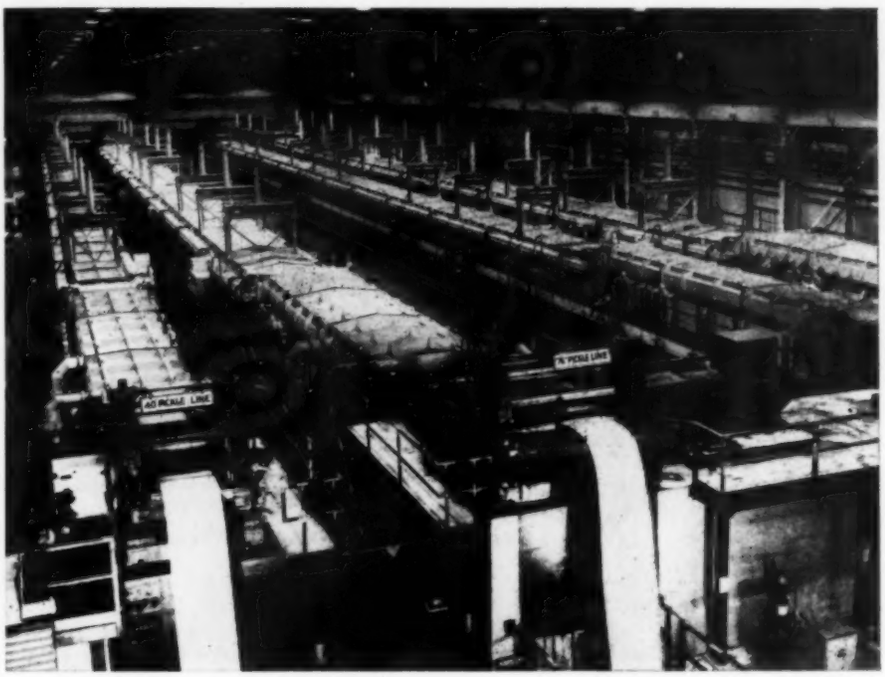
IN CANADA: National Carbon Limited, Montreal, Toronto, Winnipeg

Chemsteel CASEBOOK

ACID-ALKALI-PROOF CONSTRUCTION
CHEMSTEEL CONSTRUCTION COMPANY, INC.

Acid-Alkali-Proof Construction News of Interest to Metal Working Men

GARY MILL BOOSTS PRODUCTION WHILE REPLACING PICKLING LINES



Recent replacement of four pickling lines at U. S. Steel's Gary Sheet and Tin Mill increased production 33⅓% . . . held "down time" to 15 days a line . . . and actually started to increase total production before replacement was completed.

Through unique use of temporary beam supports, Chemsteel Construction Co., Inc. started to build permanent brick piers below beams at same time J. M. Foster & Co. installed tank shells above. Chemsteel next lined installed tank with high-temperature, acid-alkali-proof, double brick (10,000 a day!); then finished piers while Foster installed mechanical equipment. Chemsteel also installed acid-alkali-proof brick flooring.

Each old line had four 60′ acid tanks, two 35′ wash tanks, and mechanical equipment. Each new line has (1) a one-piece, rubber-and-brick-lined acid tank, 285′ long; 5′ deep—including a cold-water rinse compartment, (2) a hot-water rinse tank, 35′8″ long; 3′5″ deep, and (3) Wean equipment. Two new lines are 8′ wide; two are 5′ wide. They handle 20% sulfuric acid at approximately 220° F.

RECENT CHEMSTEEL ACID-ALKALI-PROOF INSTALLATIONS

Jones & Laughlin Steel Corp.
Aliquippa Plant

Pickling Tank in Electrolytic Tinning Line, 103′ long x 7′ wide x 3′ deep; with 139′ x 13′ x 1′ Drip Tray, Supporting Piers, and 3 Acid Sumps. Rubberlined steel shell tank has 8′ acid brick lining, joined with resinous cement.

American Steel & Wire Co.
Donora, Pa., Plant

2 Acid Holding Tanks, 20′ x 20′ x 15′ and 7 Neutralizing Tanks, 15′ x 15′ x 8′ for neutralizing waste and pickle liquors by the Iron Sulphate method. Tanks are of concrete protected by a triple layer membrane and 8″ acid brick sheathing.

Greer Steel Co.
Anderson, Ind.

Pickling tank for new backup process of pickling loose-wound coils of sheet and strip. Permits treating 8-10 coils at one time. Concrete tank, 50′ x 4′6″ x 6′ deep is protected by 3/16″ triple-layer membrane and 8″ high-temperature acid brick sheathing.

Find out how you, too, can profit from Chemsteel specialized acid-alkali-proof construction services. Write for details today!

CHEMSTEEL CONSTRUCTION COMPANY, INC. 204 CHEMSTEEL BLDG., PITTSBURGH 22, PA.

STRIP MILL CRANES

When the cranes in your Strip Mill are "Shaw-Box," you have rugged, precision engineered cranes that assure dependable service — today, tomorrow, and for years to come. The careful workmanship and advanced design details that are basic in "Shaw-Box" crane makeup insure low cost performance under the most severe requirements, with minimum attention for maintenance.

For many years, building cranes for steel mills has been an important part of "Shaw-Box" production. Our experience, understanding, and exacting standards in interpreting individual mill or AISE specifications results in sturdy cranes that operate effectively and economically on the tough work for which they are designed.

The value and dependability of "Shaw-Box" Steel Mill Cranes in maintaining production efficiency and profits is clearly demonstrated, every day, in mills all over the country.

Be sure to send all your inquiries for Steel Mill Cranes and Soaking Pit Carriages to "Shaw-Box."

MANNING, MAXWELL & MOORE, INC.
SHAW-BOX CRANE & HOIST DIVISION
MUSKEGON, MICHIGAN

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, and 'American' Industrial Instruments.

"Tycol Anepro carries heaviest loads... lowers bearing failure...slices lubrication costs"

Indeed it does! Tycol Anepro Greases measure up to severest shock-load conditions encountered in the rolling of steel. They protect bearings from moisture, heat, and abrasive impurities. Anepro's exceptionally high film strength and non-corrosive properties result in far longer bearing life . . . faster rates of production . . . minimum down-time for heavy-duty equipment.

Call or write today for complete information from your nearest Tide Water Associated office.

TYCOL

INDUSTRIAL LUBRICANTS

Boston • Charlotte, N. C. • Pittsburgh
Philadelphia • Chicago • Detroit
Tulsa • Cleveland • San Francisco

TIDE WATER ASSOCIATED OIL COMPANY

17 BATTERY PLACE - NEW YORK 4, N. Y.

SEND FOR A FREE COPY OF "TIDE WATER ASSOCIATED LUBRICANIA"

MOULDS **VALLEY** STOOLS

VALLEY MOULD & IRON CORP.

General Offices: HUBBARD, OHIO

Western Office: Chicago, Ill.

Northern Office: Cleveland, O.

MARVEL SYNCLINAL FILTERS

FACTS, NOT CLAIMS

Engineers decide on the basis of the record, on the basis of measurable facts rather than on claims of the "campaign promise" variety. Here is a fact with meaning:

OVER 200* MANUFACTURERS make MARVEL SYNCLINAL FILTERS Their O. E. M. Choice

*As of March 31, 1951

Marvel Filters are available in sump and line models, in capacities from 5 to 50 g.p.m. (multiple installations effect greater capacities), and in wire mesh sizes from 30 to 200. Line models operate in any position and may be removed without disturbing pipe fittings. For efficient filtration of non-corrosive liquids in all HYDRAULIC and LOW PRESSURE systems nvestigate Marvel Synclinal Filters.

Protect the Hydraulic System of

HUGH B. WILLIAMS HOLE DIGGERS

"Perfectly"

This Manufacturer Says:

Thomas B. Green of Hugh B. Williams Manufacturing Co., Dallas, Texas, writes: "Marvel Filters are standard equipment on our Model HDH and MDH Hole Diggers such as shown on photo. The purpose of these machines is hole digging for electrical highline poles and for foundation pier holes. These machines operate under extremely bad conditions, and we have found that Marvel Filters protect their hydraulic systems perfectly. Since we have been installing Marvel Filters we have never experienced any difficulty with foreign matter getting into the hydraulic system."

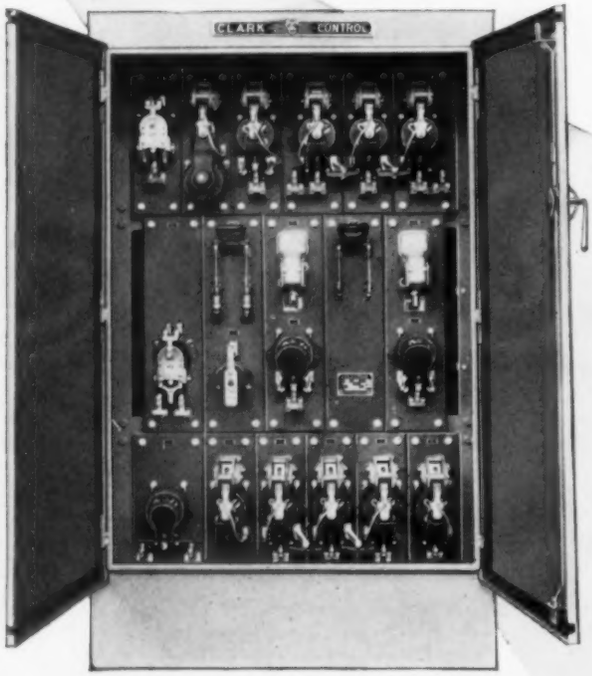
SUMP TYPE (Cutaway) LINE TYPE (Cutaway)

Write for Folder 105

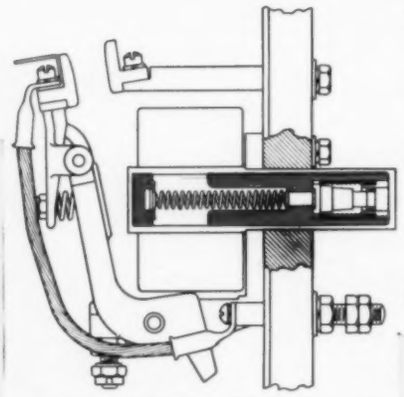
MARVEL ENGINEERING COMPANY
625 W. Jackson Blvd. Chicago 6, Ill.

CLARK CRANE CONTROL

WITH THE FAMOUS VARI-TIME PRINCIPLE



Clark Bulletin 9135, 230 Volt DC Reversing Dynamic Hoist Control, with protection, NEMA 1A *SAFE-EDGE* Cabinet, with PAN-TYPE DOORS.



Cross Section of VARI-TIME Contactor, showing operating principle.

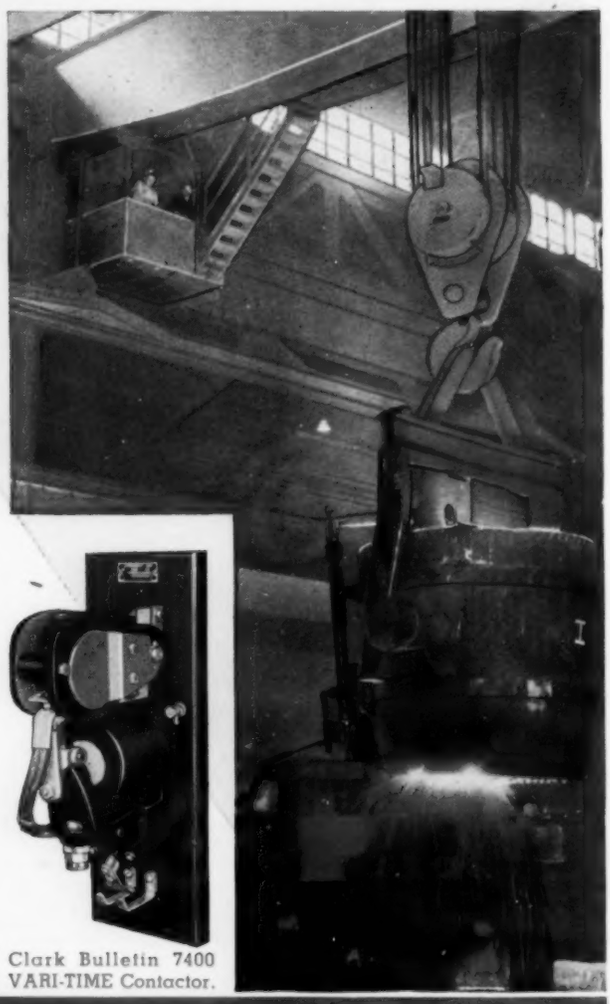
- Famous for over 20 years, CLARK VARI-TIME Contactors have had an inherent, adjustable time delay feature.
- Many accelerating relays are eliminated, thus lowering maintenance, and providing wiring simplicity.
- In active use for over 20 years, no VARI-TIME *element has ever needed repairs.*
- Thus every VARI-TIME *element is guaranteed for the life of the control.*

CLARK full magnetic Crane Controls are supplied in Unit Panel Construction as shown above, or in large panel assemblies. These Crane Controls are made in 3 standard over-all heights, and in Vault-Type cabinets with Pan-Type doors.

CLARK *dependable* Crane Controls are in use on all types of mill cranes including Ore Bridges, Hot Metal Cranes, Soaking Pit Cranes and Stripper Cranes.

CLARK CRANE CONTROL PROVIDES

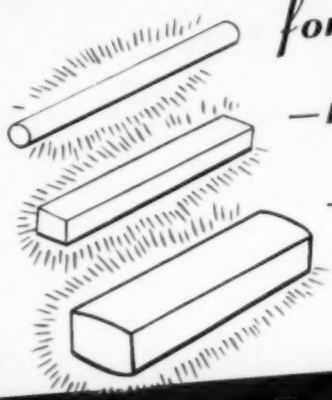
- **Definite VARI-TIME acceleration, hoisting and lowering.**
- **Slow SPOTTING speed, both "hoist" and "lower".**
- **High speed no-load hoisting and lowering.**
- **Over speed protection on final point.**
- **High torque per armature ampere by field forcing.**
- **Dynamic braking on "OFF" point.**
- **A circuit of EXTREME simplicity.**
- **Inherently stable operation.**



Clark Bulletin 7400 VARI-TIME Contactor.

THE CLARK CONTROLLER CO.

ENGINEERED ELECTRICAL CONTROL • 1142 EAST 152ND STREET, CLEVELAND 10, OHIO

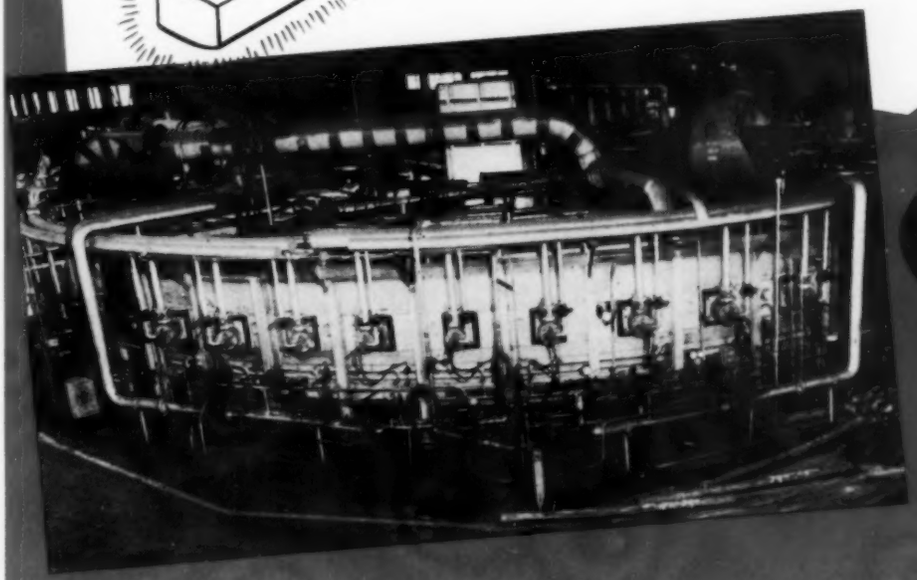


for **HEATING BARS—BILLETS—BLOOMS**

—**AUTOMATIC CONTROL OF COMPLETE HEATING CYCLE**

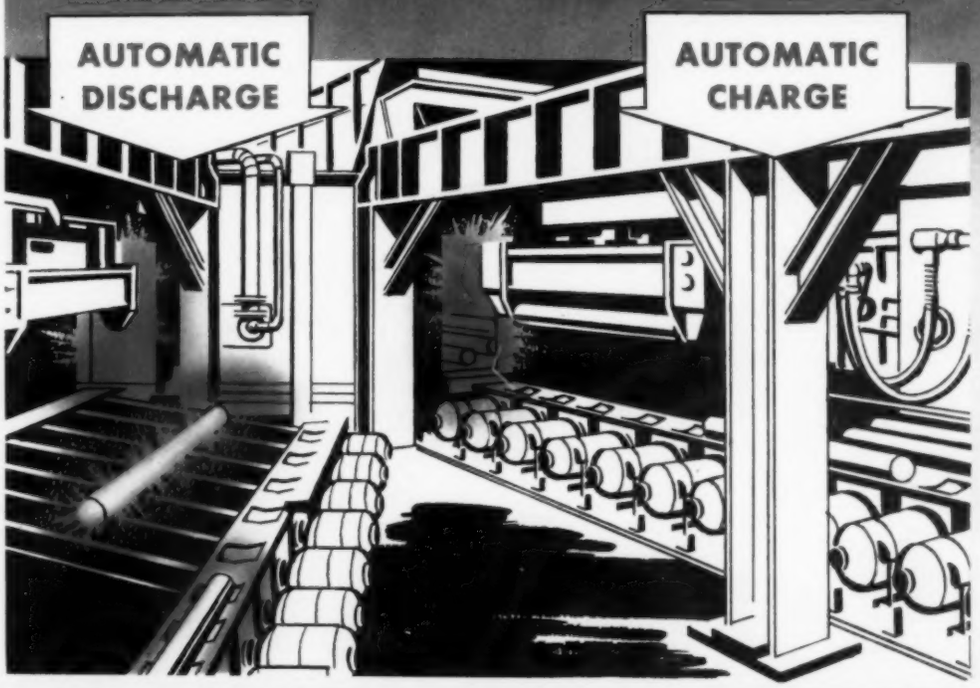
—**AUTOMATIC CHARGING AND DISCHARGING**

—**FUEL SAVINGS UP TO 36%**



Hagan

ROTARY HEARTH FURNACES



HAGAN Modern Firing Methods promote greater uniformity, produce less scale and give lower fuel consumption.

HAGAN Charger and Discharger grips stock endwise, giving greater hearth coverage and greater tonnage from a given furnace size. Grips can be adjusted within a minute for changes in length.

HAGAN Station Switch permits automatic charging of new stock on different heating cycle while stock is still being unloaded on previous setting, thereby decreasing mill delay.

HAGAN Rotary's completely automatic operation permits constant duplication of heating patterns, producing maximum yield with minimum heating cost.

Check First with Hagan FOR ADVANCED ENGINEERING IN INDUSTRIAL FURNACE APPLICATIONS

GEORGE J. HAGAN COMPANY

2402 East Carson Street

PITTSBURGH 3, PENNA.

CHICAGO — DETROIT — FT. WAYNE, INDIANA

CONTINUOUS STRIP ANNEALING in DREVER VERTICAL FURNACES

Saves Time • Reduces Cost

Outstanding PRODUCT

A Uniformly annealed strip from edge to edge and end to end of coil

B Uniform Physicals throughout the coil

C Clean, Lustrous Surface that electro-tins uniformly

D Stickers and "Dog Ears" eliminated

E Users of Continuous Annealed Strip report longer die and shear life

Drever Company has pioneered this striking improvement in Continuous Annealing Furnaces for Tin Plate Strip, Silicon Strip, Blue Plate and other strip products. We predict all major steel mills will anneal by this method. Why don't *you* do it now?

Equipment can be specified for output up to 30 tons per hour of 30″ wide x .010″ thick low carbon steel. Several sizes are available, in any width.

Furnace illustrated produces Tin Plate and Blue Plate. The shift-over from the Bright Surface required for Tin Plate to the uniformly applied, accurately controlled tight oxide coating required for blue plate is rapidly and easily made.

Installations backed by staff of Engineers and Metallurgists of sixteen years experience in Continuous Annealing of Low Carbon Strip.

Outstanding DESIGN

1 Speeds up to 1000 feet per minute

2 Controlled Strip Tension, excellent tracking

3 Controlled Heating and Soaking Time

4 Regulated Cooling Rate

5 Predictable Strip Temper

6 Cleaning in same line

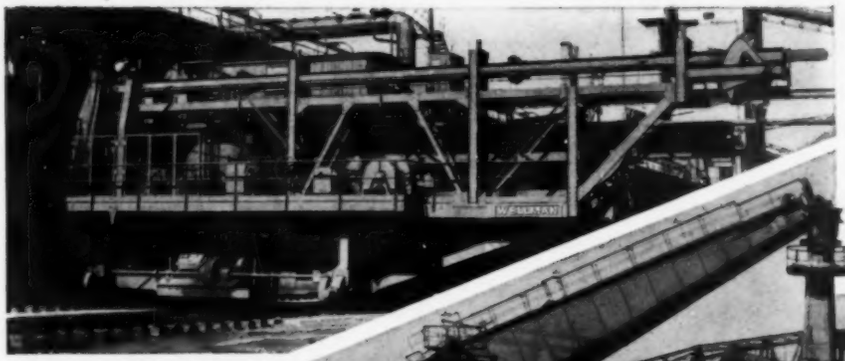
7 Low Maintenance

8 Reduction in Floor Space

9 Reduction in Coil Inventory

10 Overall Saving in Annealing and Cleaning Costs

DREVER CO.
730 E. VENANGO STREET
PHILADELPHIA 34, PENNA.



Top—*Wellman Coke Pusher at the Lorain Works.*

Center — *One of two Wellman 20-ton Hulett-Type Ore Unloaders at the Lorain Works.*

Bottom — *Three Wellman 12-ton Low-Type Open Hearth Charging Machines at the Lorain Works.*

How Wellman serves the Lorain Works

● These pictures show three important applications of Wellman equipment at the Lorain Works of National Tube Company. These installations are typical of the contributions which Wellman has made to the steel industry for more than 50 years.

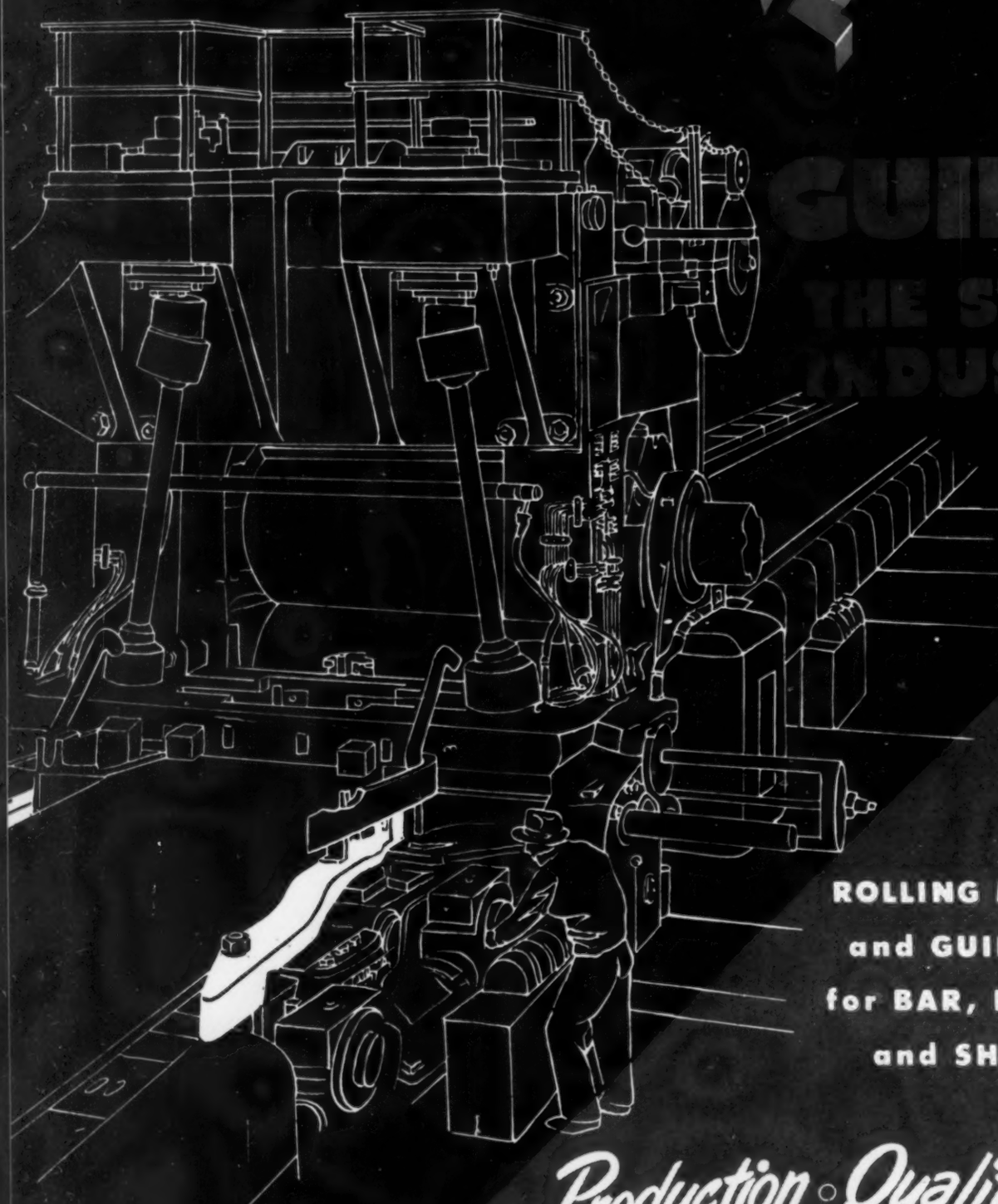
Wellman is recognized the world over as a pioneer and leader in the engineering, manufacturing and installation of heavy duty machinery for the steel industry. We welcome your problems.

THE WELLMAN ENGINEERING COMPANY

7031 CENTRAL AVENUE • CLEVELAND 4, OHIO

TRANTINYL

GUIDES THE STEEL INDUSTRY



ROLLING MILL GUIDES
and GUIDE ROLLERS
for BAR, HOOP, STRIP
and SHAPE MILLS

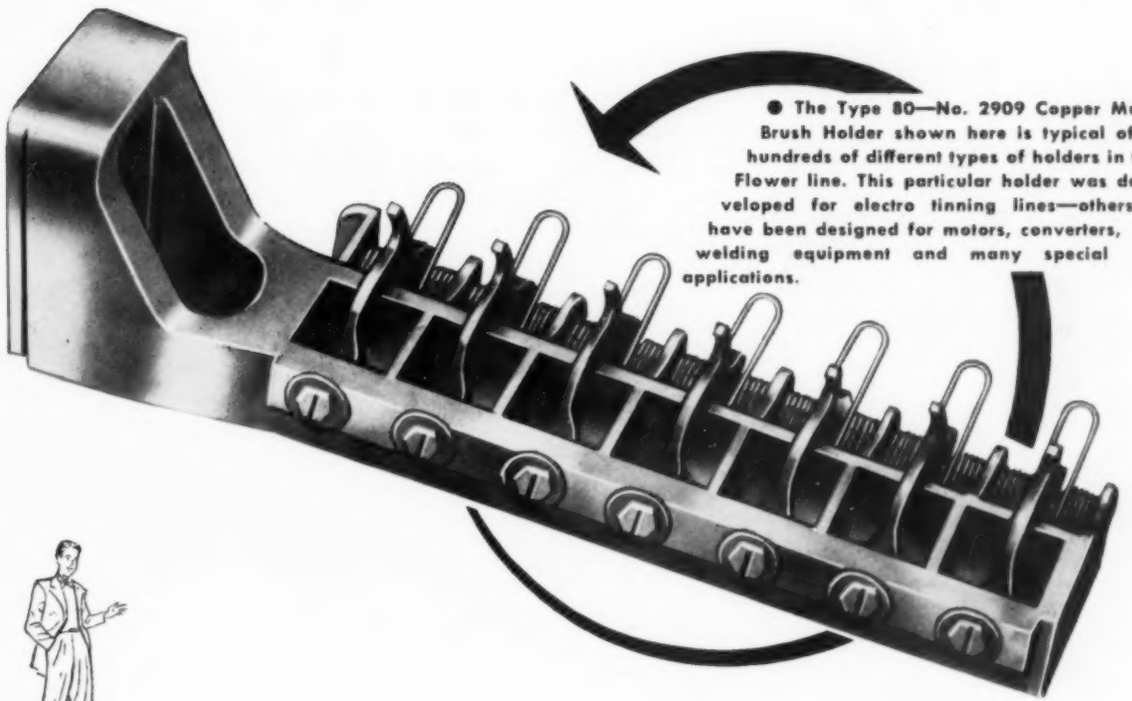
Production · Quality · Yield

Youngstown Alloy Casting Corp.
Youngstown, Ohio

Down With "Down-Time"!

Specify FLOWER Electric Brush Holders

- SAVE VALUABLE TIME
- GET PEAK PRODUCTION
- ENGINEERED FOR MAXIMUM PERFORMANCE



● The Type 80—No. 2909 Copper Multiple Brush Holder shown here is typical of the hundreds of different types of holders in the Flower line. This particular holder was developed for electro tinning lines—others have been designed for motors, converters, welding equipment and many special applications.

Why spend your profits on "down-time"? Engineers everywhere are specifying proven Flower Brush Holders—they know that for more than forty years Flower has been specializing in brush holder design. Every Flower holder is built for the job. Using modern non-corrosive materials, they are rigid and amply proportioned—they last longer, save maintenance dollars and help eliminate costly "down-time".

An experienced field engineering staff can help you with your specific application. Flower Electric Brush Holders have been specified for mill motors, railway motors, crane & hoist motors, controllers, converters, welding equipment, electro plating rolls, tinning lines, plus hundreds of other special applications. For engineering data and delivery information, contact our branch office nearest you.

FREE...

Write for Catalog No. 4

FLOWER

ESTABLISHED 1909

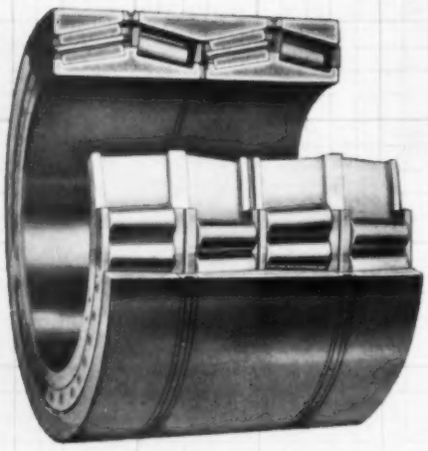
D. B. FLOWER MANUFACTURING CO.

1217 SPRING GARDEN ST.
PHILA. 23, PA.

Pittsburgh • Cleveland • Chicago • Cincinnati • Detroit • Philadelphia • Logan, W. Va. • Los Angeles • Morristown, Tenn.

more tons per turn...

TORRINGTON ROLL NECK BEARINGS



It takes bearings with rugged construction and sound metallurgy to keep roughing stands operating continually. In the rougher and other stands in Carnegie-Illinois Steel Corporation's 80" hot strip mill at Gary Sheet and Tin Mill, Torrington Roll Neck Bearings provide these and other advantages.

Four rows of tapered rollers provide high radial and thrust capacity. The reduced cross-section of these bearings allows larger roll necks for maximum rigidity. Minimum friction allows rapid acceleration with improved quality and uniformity of gage of sheet.

These Torrington Roll Neck Bearing features add up to economical operation, greater production and lower maintenance. Specify Torrington Bearings for your mill stands and auxiliary equipment.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District Offices and Distributors in Principal Cities
of United States and Canada

TORRINGTON *TAPERED ROLLER* BEARINGS

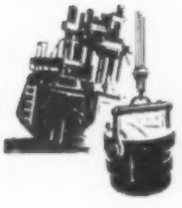
SPHERICAL ROLLER · TAPERED ROLLER · STRAIGHT ROLLER · NEEDLE · BALL · NEEDLE ROLLERS

...rapid radiation-slower burninq
...like INTERNATIONAL GRAPHITE ELECTRODES

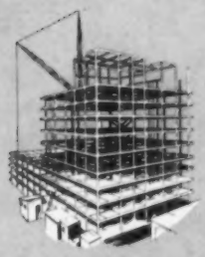
INTERNATIONAL Graphite & Electrode CORP.

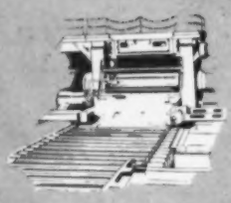
A SPEER CARBON COMPANY SUBSIDIARY

ST. MARYS, PENNSYLVANIA



Foundations — Installation of *Industrial Equipment*





Eichleay service includes the complete installation of all types of industrial equipment. All work conforms to the best engineering practice and is performed promptly with a minimum of interruption to other plant activities.

Your inquiries are invited on all types of Industrial Construction, whether it involves the installation of one machine or the erection of a complete plant.

EICHLEAY CORPORATION

33 S. 19th St., Pittsburgh 3, Pa.

681 Market Street • San Francisco 5, Calif.

HERE'S PROOF

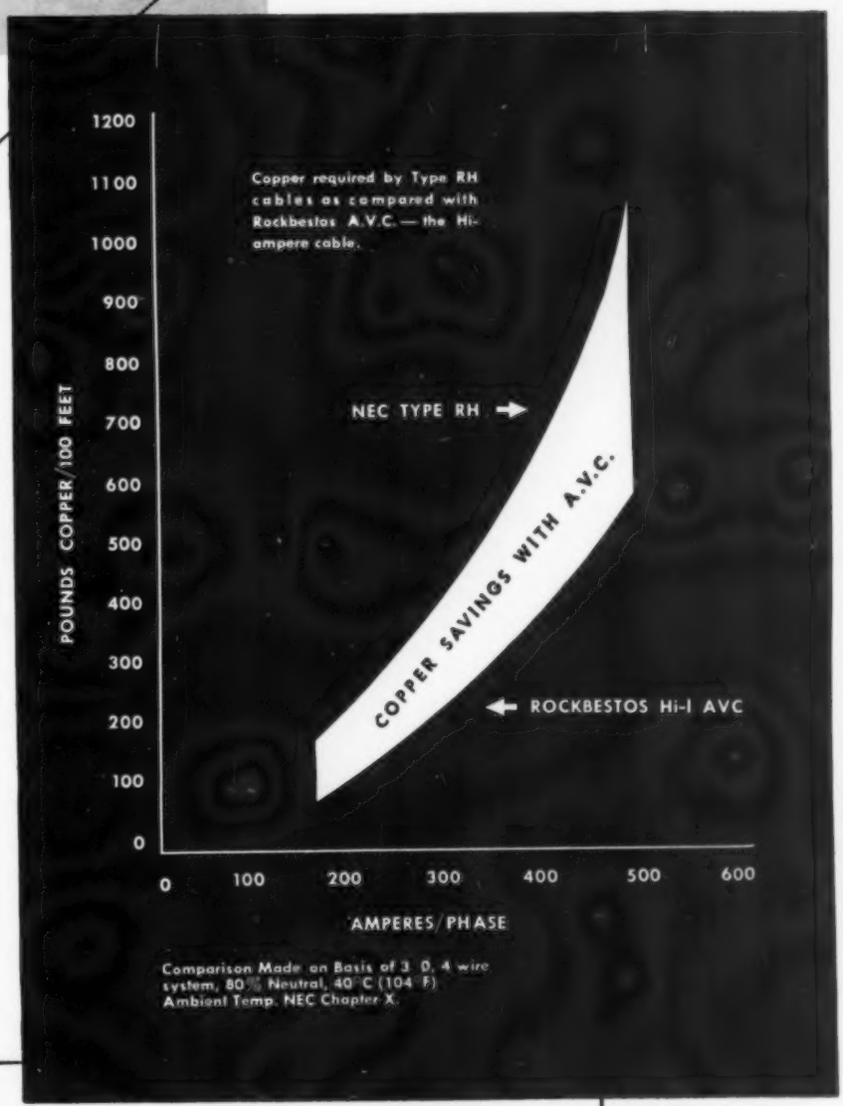
1 lb. of copper will
do the work of 1.6 lbs.
when you use

Hi $I = \frac{E}{R}$

ROCKBESTOS A.V.C.®

(CODE TYPE AVA)

Your best buy



Size for size Rockbestos A. V. C. carries more current than ordinary cables. And that's why it makes your critical copper and steel go farther.

You always use a smaller cable with Rockbestos A.V.C. Smaller cable requires less copper and smaller conduits and fittings on your power circuits. You save copper — save steel — save time and money.

Where voltage drop and power losses are critical, proper engineering allowances should be made.

Call your Rockbestos Application Engineer *today*. Ask for a copy of "Rx for a Building with Hardening of the Arteries."

ROCKBESTOS PRODUCTS CORPORATION

NEW HAVEN 4, CONNECTICUT

NEW YORK ST. LOUIS CLEVELAND LOS ANGELES DETROIT OAKLAND, CALIF CHICAGO PITTSBURGH NEW ORLEANS

10-TON, 29′-1½″ SPAN O. H. FLOOR CHARGER

BUILT BY MORGAN Engineering

DESIGNERS • MANUFACTURERS • CONTRACTORS

BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS

ELECTRIC TRAVELING CRANES • CHARGING MACHINES

INGOT STRIPPING MACHINES • SOAKING PIT CRANES

ELECTRIC WELDED FABRICATION • LADLE CRANES

STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES

SPECIAL MACHINERY FOR STEEL MILLS

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO PITTSBURGH—1420 OLIVER BUILDING

Illustrated is a Morgan 10-Ton High Visibility Floor Charger with hydraulic hoist and box clamp.

By using a hydraulic hoist, the large hoist motor with its reduction unit usually used, is eliminated, thus providing maximum visibility for the operator.

A hydraulically operated head at end of peel clamps the box head so the box will not "flop around" when turned.

Four (4) take-up reels for handling the motor leads are provided, thus eliminating twenty (20) conductor angles on the bridge.

Trolley is carried on four (4) top running wheels with two (2) kick-up wheels. The two rear upper and kick-up wheels are spring suspended for absorbing shocks when picking up loaded boxes.

Equipment News...

LIFT CARRIAGE ASSEMBLY

▲ A new, special lift carriage assembly developed by the Baker Industrial Truck division of Baker-Raulang Co. makes a 2000 to 4000 lb capacity fork truck a multi-purpose handling machine.

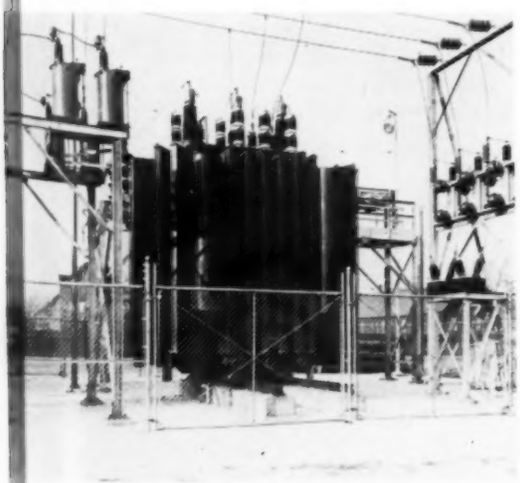
From one adjustment it functions as a standard fork truck for pallet and ordinary fork truck handling, as a clamp truck for handling drums, cartons, skid boxes, etc., and as a fork-spacer permitting the handling of varying widths of pallets, skids or other loads. A simple change in the adjustment converts it into a side-shifting fork truck which speeds many carloading and storing operations by making it easier to line up loads in close quarters.

It takes less than a minute to convert from fork-spacer and clamp to side shifter. No tools required. The conversion is made by quickly changing one pin and block. Lateral movement of the forks in each case is operator-controlled by a lever conveniently located on the dash. Action is hydraulic, with roller conveyor chain linkage.

Available in 36 in., 42 in. and 48 in. outside fork spread it provides 17 in. of fork-spacer and clamp action and as a side shifter provides four and one-quarter inches lateral movement each side of center.

With drum shoe attachments for use with clamping action the 36 in. unit will handle drums and other cylindrical objects up to 24¾ in. in diameter.

POWER TRANSFORMER



This Wagner power transformer is installed at the Chicago, Ill., South works of U. S. Steel Co. It is rated 20,000 kva self-cooled or 26,667 kva forced air cooled, and steps down 66,000 volts delta to 23,000 volts wye for distribution to the plant's substations. Wagner also builds a complete line of unit substation transformers, 100 to 2000 kva, in liquid-filled and dry-type designs.

HOISTING SPEEDS

▲ According to Mercury Manufacturing Co., hoisting speeds of fork trucks are a critical consideration in plants, warehouses and shipping departments where large volumes of pallet-loaded materials must be moved quickly each day. Any method for saving time by speeding fork-truck operations naturally results in appreciable yearly cost savings. Often overlooked is the fact that similar fork trucks can have different hoisting speeds.

The critical considerations here are not so much the weight and operational capacities of the truck, but rather the rated voltage of the power source. Because the lifting speeds of battery-powered fork trucks are almost directly proportional to the impressed voltage for a given load, higher voltages will provide faster lifting speeds. Hoisting-speed increases of 15 to 20 per cent by this method are not uncommon.

Therefore, when considering the purchase of new equipment or the possibility of increasing the capacity of existing equipment, it is advisable to investigate the economics of a higher-voltage power source.

This does not imply that it is always more economical to operate fork-trucks at the highest possible speeds. There are many installations where the capacities of existing equipment are equal to and even greater than the plant's most critical material-handling needs. Naturally, in cases such as these, it would not be wise to install larger batteries.

However, in plants, warehouses and shipping departments where fork trucks are in almost constant use, any gain in time or speed will allow the same number of trucks to do considerably more work. For an example of how a larger power source can increase fork-truck hoisting speeds, let us look at the speeds of a 5000-lb truck under two voltage conditions.

Fork Truck Hoisting Speeds*

Truck capacity (lb)	Battery voltage			
	30 Volts		36 Volts	
	Forks unloaded	Forks loaded	Forks unloaded	Forks loaded
2000	33	26	38	30
3000	33	25	38	29
4000	33	22	38	26
5000	29	14	34	18
6000	29	13	34	17
7000	20	11.5	24	14
8000	20	10	24	12

*Hoisting-speed values for these battery-powered fork trucks are in fpm.

When powered by a 30-volt industrial battery, this truck has average hoisting speeds of 29 fpm with empty forks and 14 fpm when loaded to capacity. However, when powered by a 36-volt power source, the same truck can lift its unloaded forks at a speed of 34 fpm and capacity loads at 18 fpm. This represents a hoisting-speed gain of approximately 17 per cent.

Similar possibilities exist for larger and smaller industrial trucks. The accompanying table lists average hoisting speeds for 2000-lb to 8000-lb capacity trucks when powered by 30- and 36-volt batteries.

Speeds for telescopic trucks in the

second stage of hoisting are slightly less than the tabulated values. This is because of the greater weight and the additional friction.

FURNACES FOR ITALY

▲ Design, engineering and materials for two continuous slab heating furnaces and a rotary hearth furnace for the Fiat plant of the Societe Des Automobiles at Torino, Italy, are being furnished by Rust Furnace Co.

The two Rust triple-zone fired slab heaters will serve a strip mill. Each has a capacity of 25 metric tons per hour.

The rotary hearth furnace with a capacity of 11 metric tons per hour will serve a piercing mill. It will be used to heat small ingots and billets prior to piercing. Round ingots, 6 to 7 in. in diameter up to 28 in. in length, and 2 and ¾-in.-square billets up to 19 and ¾ in. in length, will be charged cold into the rotary hearth which is triple-zone fired with automatic controls.

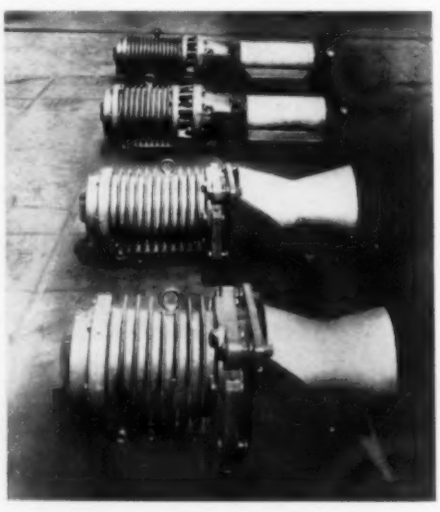
MOTOR ROLLER UNIT

▲ A recent development of the Loewy Rolling Mill Division of Hydropress, Inc., is an individually driven, motor roller unit. The new unit is specially designed for heavy duty service in rolling mills, pipe mills in back of hydraulic press installations and other plants where conveyor tables are required.

Because the speed of the rollers adjusts automatically to the weight of the load transported, the danger of overloading is eliminated. The rotor has the low inertia necessary for constant start-stop operation. Stator winding wires are glass-insulated and impregnated with silicon varnish capable of withstanding temperatures up to 350 F. If stopped by accident, cooling ribs allow the motor to be safely stalled under full load for approximately half an hour. A large cavity under the bearings permits packing with high temperature silicon grease.

Each roller is directly driven by an individual motor without couplings, reduction or bevel gears. The roller motor and supporting bracket form a self-contained unit which can be readily mounted in any desired table pattern. Straight, zig-zag, curved, spiral and s-shape lines can be installed with single groups controlled individually. Skids can easily be

One or two spare rollers are sufficient for the upkeep of an entire installation.



IS HEAT SLOWING UP YOUR WORKMEN?

TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS

TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

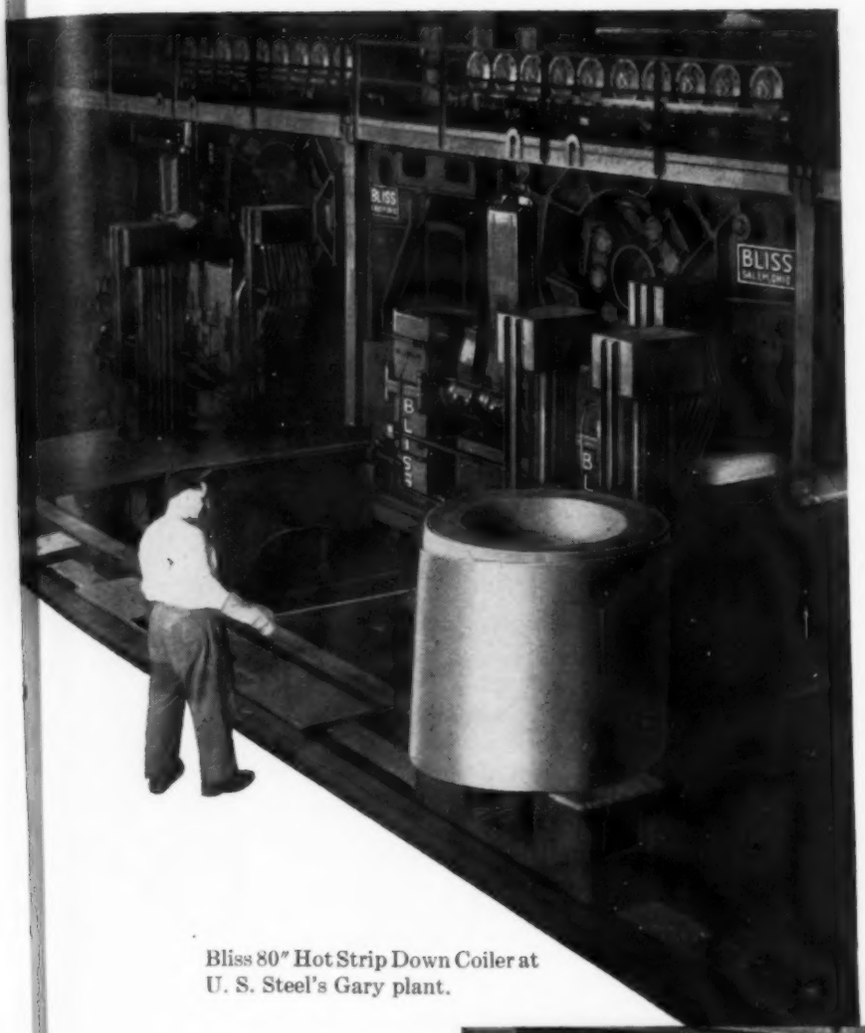
All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY

245 MAIN ST., HARMONY, PA.

Another Bliss Original



Bliss 80″ Hot Strip Down Coiler at U. S. Steel's Gary plant.

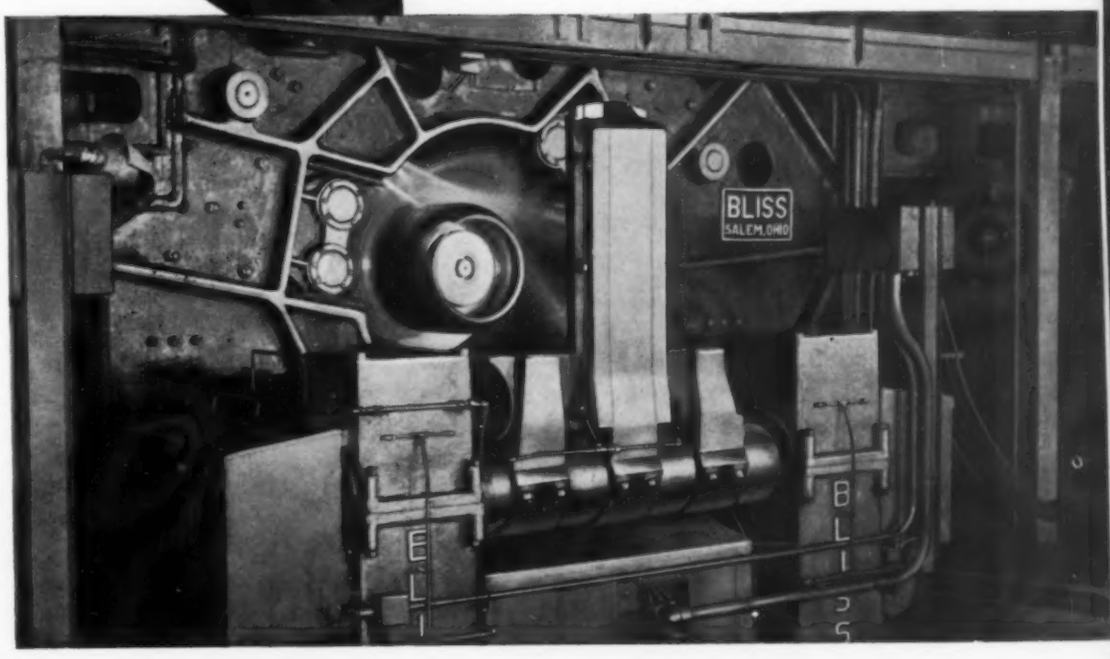
Tightly wound, smooth-edged coils that make for easy stacking and handling, quick ejection of finished coils, fast winding speed, extreme versatility as to gage and coil width, easy maintenance and minimum blocker roll wear—those are results this 80″ Hot Strip Down Coiler gives. Engineered and built by Bliss for the United States Steel Company it's the first design to use an expanding mandrel, which makes possible *all* these results.

There were engineers who said it couldn't be done for hot strip, but Bliss succeeded where others would not try.

Hot or cold rolling of ferrous or non-ferrous metals...2-, 3-, 4-high, or cluster mills ...Bliss builds them all to meet your requirements. For keen engineering counsel on rolling mills, as on presses, put your problem up to Bliss.

E. W. Bliss Company
General Office: Canton, Ohio
Rolling Mill Division
Salem, Ohio

Action photograph of coiler producing a coil.



Remember . . .
for Rolling Mills, Presses, Special Machinery . . . ***It's Bliss***

IPM

ENDS COSTLY SHUT-DOWNS of motors and generators

IDEAL PREVENTIVE MAINTENANCE

protects you against shut-downs and high cost overhauls resulting from commutator and slip ring failure. IPM keeps motors and generators at peak efficiency . . . *without dismantling*, and with only simple, routine maintenance. It insures you of using the methods and equipment that have proved most practical and economical in eliminating commonly encountered commutator and slip ring troubles. IPM has improved operating dependability and efficiency—*and reduced costs*—at many of the nation's largest users of electric motors and generators. It can do as much for you!

Get this FREE handbook of practical help!

procedures and methods developed by independent authorities on commutator and slip ring maintenance. What to do and how to do it!

Forty pages, profusely illustrated.

MAIL COUPON TODAY

IDEAL INDUSTRIES, Inc.
1045 Park Avenue, Sycamore, Ill.

Please send your free maintenance handbook and further information on:

☐ Flexible Abrasive ☐ Resurfacers
☐ Precision Grinders ☐ Undercutters
☐ Commutator Cleaners ☐ Other Tools

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE____

placed between the units and free passage can be arranged between rollers where required.

The reversible a-c motor is built to a special design of a new sturdier type. Steel shafts, which support the heavy anti-friction bearings wherever they are under strain, can be made shockproof by spring support. The squirrel cage motor itself is entirely shockproof, and, therefore, does not require a flexible coupling between the rotor and transporting roller.

The slot in the supporting bracket which carries the unit is perpendicular to assure rigid mounting of motor and roller in horizontal position. Each unit can be lifted from the supporting bracket without dismantling because the slot is open at the top. Flange mountings on the motor simplify precision alignment of the motor with the roller.

One of the prime advantages of these rollers is the extremely low maintenance cost. One or two spare rollers are sufficient for the upkeep of an entire installation which reduces spare parts to an absolute minimum. In comparison to conventional roller tables, the Loewy units do not require special crews for checking and replacing gears, couplings, bushings and other machine parts. In addition these units consume less current than any other roller conveyor.

WRAPPED JOINT

▲ Electro Chemical Engineering & Mfg. Co. announces the development of a new type wrapped joint for Haveg and other resin-base pipe, known as the "Duro-Joint." It is composed of a spiral wrapping of glass cloth and "Lecite" acid and alkali-proof furan resin cement using a special technique and is equal in strength and chemical resistance to the pipe itself. The new type joint replaces in many instances, the flange type joint which is subject to corrosion, and also may be used to repair broken pipe or to armor porcelain or stoneware.

The joint can be made in the field without the use of heat or special equipment. These joints were tested without failure under hydro-static pressure pulsating rapidly from 0 to 350 psi. The joints were then placed under 100 lb steam pressure and while hot, the pressure was released and the joint immersed at once in water at 60 F. The joints were unaffected by this shock treatment. While under 350 psi pressure, the joints were subjected to repeated blows of 8 ftlb. At the conclusion of the above tests, the new joints showed no leakage or damage.

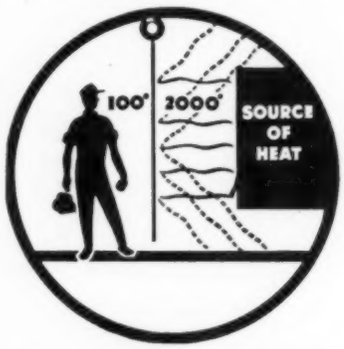
PROTECTIVE CLOTH

▲ A flexible, protective cloth, called "Ray-Foil," has been developed that protects personnel and equipment from high radiant heat and other high temperatures. It reflects radiant heat like a mirror reflects light.

Tests under actual working conditions recorded a temperature of 2000 F in the area on the exposed side of "Ray-Foil" and a temperature of only 100 F on the other side.

The cloth has numerous uses in high temperature areas not only for protection but to drastically reduce down time.

At the open hearth, no down time is required when rebuilding end or side wall burn-outs, because a shield can be set up between the heat and the wall section being rebuilt. It can



Tests recorded a temperature of 2000 F on exposed side of the cloth and a temperature of only 100 F on the other side.

be set up permanently between high temperature areas and bearing units and motors to reduce costly breakdown, grease consumption, bearing check-ups and oilers' time and the destructive effects of radiant heat.

It can also be used in coke ovens, fire and salvage departments, boiler rooms, and in research and testing laboratories.

The cloth can be used as a curtain or drape, a shield to be carried, a heat or glare baffle, or as a stand shield with a "Spa-Fla" — a portable, fire-resistant canvas wire shield designed to protect personnel and property from arc flash and welding sparks. "Ray-Foil" is also highly efficient when

used for aprons, insoles, gloves and other clothing accessories.

Distributed by Safety First Supply Co., the laminated foil-cloth is available in 100 yd × 3 ft rolls, cut lengths 3 ft wide, "Ray-Foil" tape in 2 in. × 72 yd rolls, and on a 48 × 72 in. "Spa-Fla" shield (covering either one or both sides).

ROLL STRAIGHTENERS

▲ Lone Star Steel Co. has placed a contract with Sutton Engineering Co., Bellefonte, Pa., for the straightening equipment to be installed at their new electric weld pipe mill now under construction at Lone Star, Texas.

Two rotary straightening machines will be furnished by Sutton Engineering for the full range of pipe sizes from 1.900 in. to 16 in. in diameter.

One machine will be used for straightening 1.900 in. outside diameter to 6.625 in. outside diameter pipe and the other machine for 4½ in. outside diameter to 16 in. outside diameter pipe.

The larger unit is a Sutton No. 5 M KTC 7-roll straightener equipped with power operated screwdowns and automatic angling device for all straightening rolls. This machine will operate at a straightening speed of 50 to 200 fpm using a 200 hp adjustable speed d-c motor.

The smaller machine is a Sutton B type 5-roll Straightener powered with a 75 hp variable speed motor and operates at production speeds of 60 to 240 fpm.

MECHANIZED HANDLING

▲ Mechanized materials handling has reduced the loading time of five annealing furnaces from all day to two hours at Fafnir Bearing Co., New Britian, Conn.

Floor space in the four Fafnir plants in New Britain totals nearly 19 acres in four and six-story buildings.

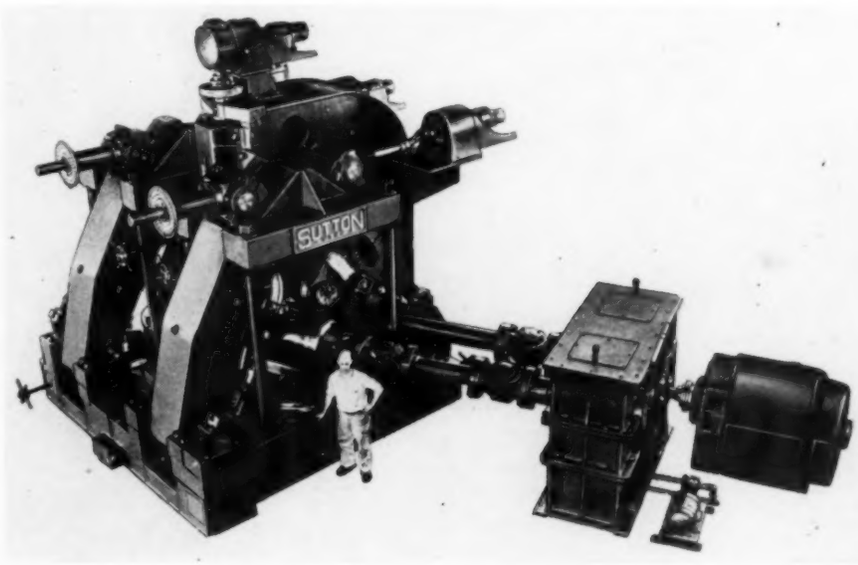
Fafnir uses its materials handling equipment in both standard and unusual ways. Virtually all parts are carried by fork lift or platform trucks at some stage of production. Trucks used for this purpose include 2000-lb capacity electric-powered Automatic fork trucks, equipped with rollover forks, and platform-type driver-led Transporters, all made by the Automatic Transportation Co.

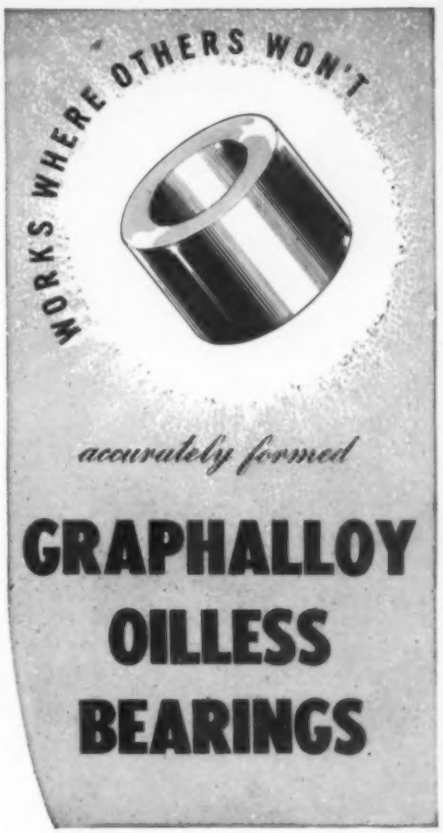
Typical operations include intradepartmental runs of from 200 to 600 ft with bins of partly finished products. This operation, Fafnir reports, has saved a high percentage of handling costs.

A "let's try it" attitude is prevalent throughout the plant. The method of loading of the annealing furnaces with forged rings or hoods in cast-iron bins is part of this. The Automatic fork truck takes the bins and places them three in a row on the furnace car, which the fork truck then pushes into the furnace.

Another problem solved by mechanical methods is chip and scrap handling. Here, the Automatic's rollover forks are employed to dump the en-

Shown is the 7-roll straightener to be installed at Lone Star Steel Co.





SPECIFY GRAPHALLOY TRADE MARK REG. U.S. PAT. OFF. WITH CONFIDENCE

SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — OR *SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS* ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — *even where oil solidifies or carbonizes* ● EXCELLENT AS A CURRENT-CARRYING BEARING.

GRAPHITE METALLIZING CORPORATION

1005 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

No. 1551-N3
¾ Inch Neutral Position 3-Way Air Valve

HAND OPERATED Air Valves

Thousands of Uses Throughout Industry

● Universally used and endorsed. Valving mechanism has stainless steel body and push-pull rods, brass sleeves, self-sealing U-packers and many other refinements, all fully enclosed against dirt, assuring long efficient trouble-free operation. No metal to metal seating. ⅜" to 1½" sizes, 3-way and 4-way, neutral position and regular actions. Pipe header mounting plates furnished if desired. *Write for full details.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

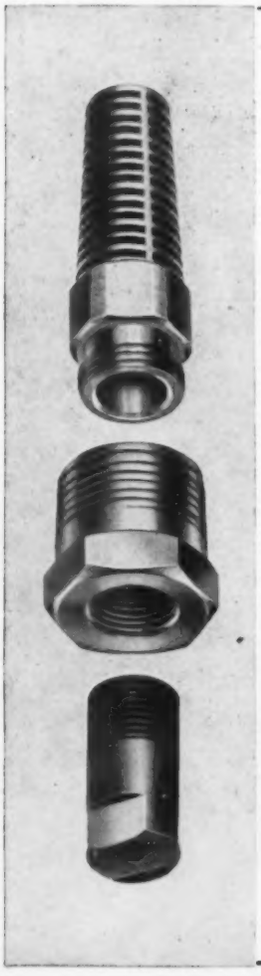
Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1988 East Pershing St., Salem, Ohio

Rollover fork trucks are used for scrap handling at this manufacturing plant.

tire load directly into bins or highway trucks. This technique produced a considerable saving in handling, and the fork truck paid for itself in less than a year.



UNIFORM descaling

with the Spraying Systems Descaling Nozzle

This hardened stainless steel nozzle provides a constantly uniform flat spray for clean descaling operations . . . all streaking is eliminated. Available in wide range of capacities.

LARGE DIAMETER ORIFICE

Note that the orifice is almost circular in shape . . . far less tendency to clog than the "old style" slotted orifice. Initial cost is lower. Maintenance cost is lower.

Write for complete information on this quality built nozzle and its large capacity strainer and adapter. Ask for Catalog 22 and Data Sheet 3997.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET
BELLWOOD, ILLINOIS
(Suburb of Chicago)

Plan to Attend

AISE SPRING CONFERENCE

NETHERLAND PLAZA HOTEL

CINCINNATI, OHIO

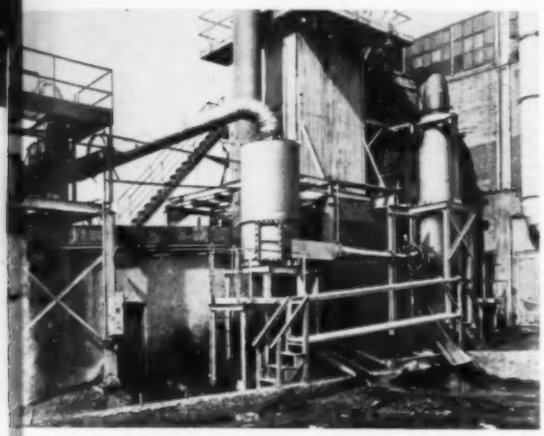
APRIL 28-29, 1952

SCRUBBER INSTALLATION

▲ Electric Storage Battery Co., manufacturers of Exide batteries, recently installed this Pease-Anthony Venturi scrubber at their plant in Philadelphia, Pa. The scrubber is used to remove lead dust from exhaust gas produced by a blast furnace in which lead scrap is melted.

Hot gases enter the top of the conditioning tower (right) where they are sprayed with water to condense volatile materials. From there, gases enter the Venturi, are accelerated at the throat section (center) and are impacted by multiple jets of low velocity water.

In the centrifugal separator (left) the atomized liquid, containing a high percentage of lead dust originally suspended in the gas, is removed. In this installation, the scrubber is constructed of stainless steel. The fan (extreme top left) draws the gases through the equipment.



This scrubber is used to remove lead dust from exhaust gas.

Quick-As-Wink AIR AND HYDRAULIC Control Valves

No. HH-551-N4 — ¾" 4-Way Neutral Position Hydraulic Valve

LEVER OPERATED Hydraulic Valve

For water or oil hydraulic systems to 5000 p. s. i.

● Unsurpassed for efficient trouble-free service controlling double acting hydraulic cylinders and other important high pressure hydraulic circuits. Positive, fast acting. All parts are in pressure balance, eliminating any tendency to creep or crawl. Machined steel housing, chrome plated and polished stainless steel plungers. Self sealing U-packers. Metal valving rings take the impingement of the liquid, preventing wear on the packings. ½" to 1½" sizes. Available also in pilot operated designs up to 4". *Write for full details.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink AIR AND HYDRAULIC Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1982 East Pershing St., Salem, Ohio

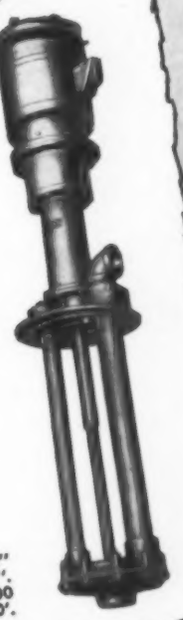
Give enough!

FOR ALL RED FEATHER SERVICES

Built for the Grind

- No stuffing box
- No submerged bearings
- No priming problem
- No trouble

for ASH HANDLING DRAINAGE PUMPING ABRASIVE or CORROSIVE MATERIALS



Nagle Type "SW-OB" Pump. Sizes 1" to 8". Capacities up to 1800 g.p.m. Heads up to 100'.

Nagle Pumps, Inc.

INDUSTRIAL PUMPS FOR ABUSIVE APPLICATION

1263 CENTER AVENUE, CHICAGO HEIGHTS, ILLINOIS

New Members AISE

Active

JULES ANTOINE
Superintendent Hot Strip Mill
Experance-Longdoz
(Division de Jemeppe)
Liege, Belgium

R. H. BARRICK
Superintendent of Processing Departments
Atlas Steels, Limited
Welland, Ontario, Canada

THOMAS A. BEATTIE
Relief Foreman, Maintenance Shops
National Tube Co.
McKeesport, Pa.

AMOS C. BLEDSOE
Division Superintendent Sheet & Tin
Fairless Works
United States Steel Co.
Pittsburgh, Pa.

W. E. BOGER
Superintendent of Rolling
Alan Wood Steel Co.
Conshohocken, Pa.

CARL F. CERULL
Assistant Chief Engineer
Republic Steel Corp.
Youngstown, Ohio

CHARLES E. ERICKSON
Assistant Electrical Foreman
Bethlehem Steel Co.
Lackawanna, N. Y.

JAMES E. FARLEY
Electrical Engineer
Republic Steel Corp.
Cleveland, Ohio

HENRY S. GORDON
Assistant Works Chief Engineer
United States Steel Co.
Gary Sheet & Tin Mill
Gary, Ind.

JOHN R. GRAMAS
Methods Engineer
Columbia Steel & Shafting Co.
Pittsburgh, Pa.

RICHARD R. GURREN
4-High Operator (Assistant Roller)
Crucible Steel Co. of America
Midland, Pa.

W. W. HINTALLA
Metallurgist, Sheet Division
Gary Sheet & Tin Mill
United States Steel Co.
Gary, Ind.

KENNETH R. HOUGH
Assistant Sup't. of Rod Mills — Rod Yard
Pittsburgh Steel Co.
Monessen, Pa.

V. W. JOHNSON
Superintendent Rolling Mills
Colorado Fuel & Iron Corp.
Pueblo, Colo.

HENRY E. KEIL
General Foreman
Power Generation & Transmission
United States Steel Co.
Clairton, Pa.

THOMAS E. KINNEY
Transitman
National Tube Co.
Morrisville, Pa.

ALLEN B. LARASON
Draftsman
National Tube Co.
Morrisville, Pa.

CHARLES C. LAUTHER
Assistant Mechanical Engineer
Bethlehem Steel Co.
Lebanon, Pa.

PHILIP S. MAY
Chief of Party
National Tube Co.
Morrisville, Pa.

JOHN F. MENGEL
Bethlehem Steel Co.
Bethlehem, Pa.

C. L. METZLER
Designer and Checker
American Steel & Wire Co.
Cleveland, Ohio

HAROLD W. MILLER
Assistant General Superintendent
Carpenter Steel Co.
Reading, Pa.

E. L. MONG
Superintendent Bar Mills
Republic Steel Corp.
Canton Plant
Canton, Ohio

CHARLES R. MONTGOMERY
Chief Chemist
Pittsburgh Steel Co.
Monessen, Pa.

BENJAMIN A. PALLADINO, JR.
Junior Field Engineer
Alan Wood Steel Co.
Conshohocken, Pa.

HOWARD A. PARKER
Division Superintendent of Open Hearths
United States Steel Co
Fairless Works
Morrisville, Pa.

FRANK V. PETER
Plant Engineering — Steel Operations
Detail Draftsman
Ford Motor Co.
Dearborn, Mich.

GEORGE L. ROBSON, JR.
Lubrication Engineer
Columbia Steel Co.
Pittsburg, Calif.

D. MAXWELL SEELY
General Facilities Engineer
United States Steel Co.
Pittsburgh, Pa.

CHARLES H. SEVERS
Transitman
National Tube Co.
Fairless Works
Morrisville, Pa.

JOSEPH HENRY SIEGFRIED, JR.
Project Planning Engineer
Columbia Steel Co.
San Francisco, Calif.

ROBERT W. SMITH
Detail Draftsman
National Tube Co.
Morrisville, Pa.

JOHN H. STONE
General Foreman Merchant Mills
Youngstown Sheet and Tube Co.
Youngstown, Ohio

RALPH THOMPSON
Assistant Superintendent Maintenance
Lower Works
National Tube Co.
Lorain, Ohio

ALBERT L. VOSS
Process Engineer
National Tube Co.
National Works
McKeesport, Pa.

GEORGE E. WAGNER
Assistant Plant Superintenden
Quebec Iron & Titanium Corp.
Sorel, Quebec, Canada

J. A. WARD
Assistant Electrical Superintendent
Steel Co. of Canada, Ltd.
Hamilton Works
Hamilton, Ontario, Canada

A. WILLIAMS
Sub Foreman
Wisconsin Steel Co. I.H.C.
Chicago, Ill.

ROBERT W. WILLIAMSON
Maintenance Engineer
Columbia Steel & Shafting Co.
Pittsburgh, Pa.

JOHN F. WORDEN
Assistant to Superintenden
Electrical Department
Bethlehem Steel Co.
Johnstown, Pa.

HERMAN ALBERT BALLSTADT
Blast Furnace General Foreman
Algoma Steel Corp., Ltd.
Sault Ste. Marie, Ontario, Canada

FRED R. BEISER
Process Engineer
National Tube Co.
National Works
McKeesport, Pa.

R. R. BLACK
Designing Engineer
Compania de Acero del Pacifico
Talcahuano, Chile, South America

R. C. BRITTON
Designing Engineer
United States Steel Co.
Gary, Ind.

EDWARD H. CAUGER
Chief Combustion Engineer
Wheeling Steel Corp.
Steubenville, Ohio

R. W. COYLE
Works Engineer
The Midvale Co.
Nicetown, Philadelphia, Pa.

LEO F. CRAWLEY
Open Hearth Pyrometer Technician
National Tube Co.
National Works
McKeesport, Pa.

RICHARD M. DAVIS
Staff Assistant
Atlas Steels, Ltd.
Welland, Ontario, Canada

WELLS L. DAVIS
Development Engineer
The Babcock & Wilcox Tube Co.
Beaver Falls, Pa.

ARMAND J. DI CESARE
Practice Electrical Engineer
Wheeling Steel Corp.
Steubenville, Ohio

CHARLES N. FENDRICH
Assistant Superintendent Power and Maintenance
Bethlehem Steel Co.
Steelton, Pa.

KAZUO FUJII
Staff Engineer
Yodogawa Steel Works, Ltd.
Osaka, Japan

JOSEPH M. GRAUBARD
Design Engineer
United States Steel Co.
Construction Engineering Bureau
Pittsburgh, Pa.

LEWIS E. HALDEMAN
Designer
American Steel & Wire Co.
Cleveland, Ohio

HENRY HALTOF
Design Draftsman
United States Steel Co.
Gary, Ind.

FRED S. JOHNSTON
Assistant Chief Draftsman
Algoma Steel Corp., Ltd.
Sault Ste. Marie, Ontario, Canada

SIDNEY N. JOSEPHSON
Designer
National Tube Co.
Gary, Ind.

WILLIAM L. KAISER
Chief Production Engineer
Wheeling Steel Corp.
Beech Bottom, W. Va.

HIDEO KOHDA
General Manager (Director) in Charge of Kure' Plant
Yodogawa Steel Works, Ltd.
Osakashi, Japan

SIGMUND T. MENTZEL
Electrical Engineer
United States Steel Co.
Gary Works
Gary, Ind.

ROBERT G. MIDDLEMISS
Supervisor — Steel Works Metallurgists
National Tube Co.
National Works
McKeesport, Pa.

L. ALBERT PIERCE
Assistant Superintendent
Woodward Iron Co.
Woodward, Ala.

W. TRUXTON PURVANCE
Assistant Chief Engineer
Geneva Steel Co.
Salt Lake City, Utah

PABLO RISOPATRON
Assistant Superintendent of Blooming Mill
Compania de Acero del Pacifico
Talcahuano, Chile, South America

New Members AISE

W. P. SCHENCK
Superintendent Mining Division
Alan Wood Steel Co.
Dover, N. J.

G. W. SNYDER
Plant Combustion Engineer
Crucible Steel Co. of America
Midland Works
Midland, Pa.

WILLARD J. STRUNK
Roller 26-In. Mill
Compania de Acero del Pacifico
Talcahuano, Chile, South America

ROBERT L. TOERING
Design Draftsman
United States Steel Co.
Gary Works
Gary, Ind.

JOHN HARVEY WILKES
Roller Merchant and Rod Mill
Compania de Acero del Pacifico
Talcahuano, Chile, South America

JUAN V. ZAPATA
Assistant General Superintendent
Cia. de Acero del Pacifico, S. A.
Concepcion, Chile, South America

R. C. RITTER
Electrical Foreman
Inland Steel Co.
Indiana Harbor, Ind.

R. J. SAMMON
Roller
Kaiser Steel Corp.
Fontana, Calif.

ERNEST C. G. SOFFRONOFF
Electrical Engineer
The Midvale Co.
Philadelphia, Pa.

JOHN T. SOPKO
Operating Engineer
Jones & Laughlin Steel Corp.
Aliquippa, Pa.

ALEX A. STEFANI
Electrical Engineer
Clairton Works
United States Steel Co.
Clairton, Pa.

STEPHEN J. STONE
Senior Engineer
Inland Steel Co.
East Chicago, Ind.

R. WILLEM
Manager
Le Laminage A Froid
Carnieres, Belgium

ARCHIE WILLIAMSON, JR.
Superintendent
Mechanical and Electrical Maintenance
Tennessee Coal, Iron & Railroad Co.
Fairfield, Ala.

Associate

C. H. ANDERSON, JR.
Draftsman
United Engineering & Foundry Co.
Pittsburgh, Pa.

JOSEPH F. BREHL
Sales Engineer
National Alloy Steel Division
Blaw-Knox Co.
Pittsburgh, Pa.

JOHN W. BRINKS
Application Engineer — Steel Mill Section
Industry Engineering Department
Westinghouse Electric Corp.
East Pittsburgh, Pa.

JOSEPH CALABRESE
Design Engineer
Birdsboro Steel Foundry & Machine Co.
Birdsboro, Pa.

JOHN L. CLARKE
Mechanical Designer
United Engineering & Foundry Co.
Pittsburgh, Pa.

DONALD S. CORNEAL
District Engineer
Johns-Manville Sales Corp.
Philadelphia, Pa.

ERNEST H. DALGLISH
Proposal Engineer
Lewis Foundry & Machine Division
Blaw-Knox Co.
Pittsburgh 30, Pa.

H. F. DISCHINGER
Chief Engineer
Robins Engineers
Division of Hewitt Robins, Inc.
New York, N. Y.

SAMUEL G. DUNNING
Manager Service
Reliance Electric & Engr. Co.
Cleveland, Ohio

LEROY F. HEISER
Design Engineer
Birdsboro Steel Foundry & Machine Co.
Birdsboro, Pa.

ANDREW HLIVKA
Steel Mill Service Engineer
National Cylinder Gas Co.
Davis Island Yards
McKees Rocks, Pa.

JAMES D. McCULLOUGH
Chief Engineer
Refractories Division
Babcock & Wilcox Co.
New York, N. Y.

HARRY E. NIXON
Sales Representative
Johns-Manville Sales Corp.
Philadelphia, Pa.

LOUIS A. PARADEE
Engineer
A. J. Boynton Co.
Chicago, Ill.

A. V. PETERSON
Engineer
A. G. McKee & Co.
Cleveland, Ohio

GRAHAM ROBERT SCHOFIELD
Application Engineer
Clark Controller Co.
Cleveland, Ohio

DR. JOSEPH SCHUELLER
Director
Demag, A. G.
Duisburg, Germany

LOREN F. STRINGER
Associate Engineer
Westinghouse Electric Corp.
East Pittsburgh, Pa.

WADE H. WIGINGTON, JR.
Assistant Electrical Engineer
Morgan Construction Co.
Worcester, Mass.

DOUGLAS W. WILLIAMS
Cleveland District Manager
Babcock & Wilcox Co.
Cleveland, Ohio

A. JACKSON WINCHESTER, JR.
Application Engineer
Metal Working Section
Industry Engineering Department
Westinghouse Electric Corp.
East Pittsburgh, Pa.

JOHN K. BYRNE
Sales Manager
Complete-Reading Electric Co., Inc.
Chicago, Ill.

GEORGE V. CAMPBELL
Sales Manager
The Ramtite Co.
Chicago, Ill.

WILLIAM C. COOK
Steel Mill Engineer
Westinghouse Electric Corp.
Philadelphia, Pa.

S. Q. DAVID
Plant Engineer
Reynolds Alloys Co.
Sheffield, Ala.

S. C. DICKERHOFF, JR.
President and General Manager
Automatic Nut Co.
Lebanon, Pa.

RALPH F. DORSHIMER
Designer
Treadwell Engineering Co.
Easton, Pa.

CHARLES GEGICK
Draftsman
United Engineering & Foundry Co.
Pittsburgh, Pa.

TERRENCE GIZESKI
Supervisor
Blast Furnace Control Department
Koppers Co., Inc.
Freyn Engineering Department
Chicago, Ill.

K. E. GORDER
Control Engineer
Allen-Bradley Co.
Chicago, Ill.

K. A. GOTTSCHALK
Supervisor Industrial Power Sales
Cleveland Electric Illuminating Co
Cleveland, Ohio

DONALD H. HIPP
Vice President
Reynolds Alloy Co.
Sheffield, Ala.

JAMES A. HUDSON
Manager Process Service
The Linde Air Products Co.
Chicago, Ill.

GORDON L. LAMBERT
Project Manager and Engineer
The Rust Engineering Co.
Birmingham, Ala.

WILLIAM G. McCLAIN
Sales Engineer
E. W. Bliss Co.
Salem, Ohio

ANGUS JAMES MacDONALD
Electrical Superintendent
Aluminum Co. of Canada, Ltd.
Kingston Works
Kingston, Ontario, Canada

ALBERT A. MILKIE
Sales and Field Engineer
Robins Conveyors Division
Hewitt Robins, Inc.
Chicago, Ill.

T. K. PIPER
Contract Engineer
Chemsteel Construction Co., Inc.
Pittsburgh, Pa.

ROBERT J. POWELL
Refractories Sales Engineer
The Babcock & Wilcox Co.
Atlanta, Ga.

G. GORDON SCHMUCK
Sales Engineer
Perma-Line Rubber Products Corp.
Chicago, Ill.

JAMES B. SHEA, JR.
Industrial Engineer
Timken Roller Bearing Co.
Canton, Ohio

F. B. SHEW
District Manager
Wellman Engineering Co.
Chicago, Ill.

ANDREW J. SNIDER, III
Sales Engineer
Combustion Engineering—Superheater, Inc.
Chicago, Ill.

FRANK W. STUKER
District Manager
W. A. Jones Foundry & Machine Co.
Buffalo, N. Y.

HENRY B. WATSON
Salesman
Cutler-Hammer, Inc.
Salt Lake City, Utah

FRANK P. ZIEMKIEWICZ
Control Specialist
General Electric Co.
Pittsburgh, Pa.

The light in the "Lab"

In the research laboratories of hospitals, clinics, and medical schools throughout our country, the lights burn late . . . as scientists constantly strive to halt humanity's greatest enemy—CANCER.

As the lights continue to burn, the hope for a cure grows brighter . . . here's why:

Cancer Research Is Paying Off

Through research—which you have helped to support by donating to the American Cancer Society—medical science now has new weapons to combat this disease more effectively than ever:

Drugs—there is evidence that a chemical treatment for cancer may be perfected. Certain drugs will prolong the lives of cancer victims . . . other promising compounds are being tested.

Hormones—treatment with hormones, such as ACTH and Cortisone, has brought about dramatic, although temporary, effects in some types of cancer. Other hormones have helped control *advanced* cancer of certain organs.

X-rays—the development of more powerful machines promises to make this form of treatment more effective.

Isotopes—radioactive chemicals are becoming increasingly useful in treating certain rare forms of the disease.

In addition, surgical technics have been improved so much that once hazardous operations can now be performed safely. And progress is being made in the development of tests to detect cancer in its earliest stages when the chances for cure are best. Research has made these life-saving advances possible. But, as long as cancer continues to kill some 210,000 men, women, and children in our country each year, we *must* keep the lights burning in the laboratories! *Much more research needs to be done before cancer can be dealt the final blow!*

Your life—the life of everyone you know—is at stake. Give generously to the 1951 Cancer Crusade.

Help Science Help You . . . Give To Conquer Cancer

Mail your contribution today to

CANCER

% Your Local Post Office

. . . your gift will reach your American Cancer Society Division

CANCER,
care of Your Local Post Office

Here is my contribution of $_____ to fight Cancer.

Name_____

Address_____

City_____ Zone_____

State_____

THE ENGINEERING MART

WHERE TO BUY
EQUIPMENT FOR SALE
POSITIONS VACANT
POSITIONS WANTED

AN *IRON and STEEL ENGINEER* SERVICE TO THE STEEL MILL OPERATORS

WHERE TO BUY

CHICAGO DISTRICT

THE POST ELECTRIC CO., INC.
Electrical
Construction
Engineering
Maintenance
Since 1931
327 So. La Salle Street
Chicago 4, Ill.
Phone: WAbash 2-0750
(A Westinghouse Industrial Agent)

PAUL W. WENDT & SONS
Manhattan Building
CHICAGO 5, ILLINOIS
District Representatives for
A. W. CADMAN MFG. CO.
HUNTER SAW & MACHINE CO.
GRAFO COLLOIDS CORP.

EHRET AND KINSEY
Board of Trade Bldg., 141 West Jackson Blvd.
Chicago 4, Illinois Wabash 2-0449
Representing
THE CLEVELAND WORM AND GEAR CO.
Worm Gearing and Worm Gear Speed Reducers
THE FARVAL CORPORATION
Farval Centralized Lube Systems
LUBRICATION PRODUCTS COMPANY
Stapax Journal Box Lubricators
AMERICAN FLEXIBLE COUPLING COMPANY
Amerigear Flexible Couplings
WALDES KOHINOOR, INCORPORATED
Truarc Retaining Rings

CLEVELAND DISTRICT

For ***ACID RESISTANCE*** *on Ducts and Tank Exteriors . . .*
Specify ***CARBALT PLASTIC***
• Easily Applied • Low Cost Protection
HEIL **Process Equipment Corp.**
12901 Elmwood Ave., Cleveland 11, Ohio

PHILADELPHIA DISTRICT

TOWLE & Son Co.
18 West Chelton Ave. GE 8-1930
Representing:
PHILADELPHIA 44
THE TOOL STEEL GEAR AND PINION CO.
Cincinnati 16, Ohio

PHILADELPHIA (Continued)

MOFFATT BEARINGS COMPANY
1640 Fairmount Avenue
PHILADELPHIA 30, PA.
Phone: POplar 5-3443
A Complete Anti-Friction Bearing Service
Ball, Roller, Thrust and Needle

PITTSBURGH DISTRICT

ROLLING MILLS and EQUIPMENT
FRANK B. FOSTER, INC.
2220 OLIVER BUILDING PITTSBURGH 22, PA.
Cable Address "FOSTER" Pittsburgh

METALLIC RECUPERATORS
(Air Preheaters)
For application to soaking pits, heating, and other types of metallurgical furnaces.
HAZEN ENGINEERING CO.
Park Building PITTSBURGH, PA.
COurt 1-7032

PATTERSON-EMERSON-COMSTOCK, INC.
ENGINEERS AND CONSTRUCTORS
Specializing in Steel Mill Construction
313 E. Carson Street
Pittsburgh 19, Pa.
Phone: EVerglade 1-9800

Auburn & Associates, Inc.
Engineers
ELECTRICAL LAYOUTS FOR STEEL MILLS
923 Penn Ave., Pgh. 22, Pa.
Telephone COurt 1-5014

PITTSBURGH (Continued)

CHEMSTEEL CONSTRUCTION COMPANY, INC.
204 Chemsteel Bldg., Walnut St., Pittsburgh 32, Pa.
Send data on Engineering & Construction facilities for
ACID-ALKALI-PROOF CONSTRUCTION
of pickling and other tanks; flooring.
(TEAR OUT & MAIL WITH LETTERHEAD)

W. G. KERR CO., INC.
520 Oliver Building PITTSBURGH, PA.
Phone: ATlantic 1-4254
Representing:
FOOTE BROS.—Gears and Speed Reducers
REEVES—Variable Speed Drives
THOMAS—Flexible Couplings
SMITH—Telesmith Crushers
CULLEN-FRIESTEDT—Sheet Lifters—Welding Positioners—Track Cranes

RITTER ENGINEERING CO.
Engineers - Distributors - Contractors
3031 WEST LIBERTY AVE. Phone:
PITTSBURGH 16, PA. LOCUST 1-0128
Representing:
TRABON ENGINEERING CORP.
"Centralized Lubricating Systems"

BLAST FURNACES
Industrial Furnaces & Boilers
• Construction • Rebuilds • Linings
• Maintenance • Repair
AFFILIATED FURNACE, INC.
204 Chemsteel Building, Walnut Street, Pittsburgh 32, Pa.

PRODUCTS

for ACID-PROOF TANKS
SAUEREISEN ACID PROOF CEMENTS
Years of dependable service in leading steel mills, chemical plants, etc. A type for every acid proofing use.
Trial Order 10 lb. lot $3.30
Sauereisen Cements Company • Pittsburgh 15, Pa.

THE ENGINEERING MART
(CONTINUED)

CONSULTING ENGINEERS

LOYAL R. MILBURN
Consulting Electrical Engineer
Registered State of Michigan
1928 Guardian Building • Detroit 26, Michigan
Telephone: Woodward 3-8706 or
Whitmore Lake 5141

POSITIONS VACANT

DESIGN ENGINEER
10 to 15 years practical experience in designing Open-Hearth Furnaces. Write giving details to Employment Office.
BETHLEHEM STEEL CO.
501 E. Third St. BETHLEHEM, PA.

ENGINEER
for miscellaneous steel fabrication shop. Excellent opportunity. Steady job.
SOUTH HILLS ORNAMENTAL IRON COMPANY
2428 W. Liberty Ave. Pittsburgh, Pa.

DESIGNER • Mechanical • Heat Treating Furnaces and accessories • wanted by established industrial furnace equipment manufacturer • must be experienced • Write fully • Reply to Drever Company, 736 E. Venango St., Philadelphia 34, Pa.

Assistant Superintendent, Machine and Forge division of an aggressive well established organization in the steel industry — Supervision approximately 300 employees. Steel rolling mill equipment, maintenance and production work. Machinist background — 10-15 years with supervisory experience. High or trade school graduate, administrative ability. State age and salary desired in first letter. Address: Box No. 901, Iron and Steel Engineer, 1010 Empire Bldg., Pittsburgh 22, Pa.

INDUSTRY NEWS

(*Continued from page 228*)

BLAST FURNACE SHELL TO BE BUILT OFF SITE

▲ Affiliated Furnace, Inc., Pittsburgh, Pa., has been awarded a contract to rebuild the "A" blast furnace at Pueblo, Colo., plant of Colorado Fuel and Iron Corp. A new blast furnace shell is being erected by the CFI organization and will be moved to the present furnace foundation after the existing furnace has been dismantled by Affiliated Furnace who will then complete the project.

Colorado Fuel and Iron has also awarded to Affiliated Furnace a contract for the rebuilding and relining of the "Y" blast furnace at the Wickwire Spencer Steel Division plant, Buffalo, N. Y.

GREAT LAKES BUYS HUGE MOTOR-GENERATOR

▲ The world's largest single flywheel motor-generator set, with a 65-ton flywheel and a 9000-hp motor, will be built by Westinghouse Electric Corp. The set is part of a multi-million dollar contract awarded to Westinghouse by the Great Lakes Steel Corp. for electrical equipment to power a new slabbing mill to be erected in Detroit. Also included in the order are the mill's main and auxiliary drives, and alternating current and direct current auxiliary power equipment.

The motor-generator set's 65-ton flywheel, with a capacity of 250,000 hp—second stored energy, will insure a uniform drain on the mill's power supply, even when ingots are entering the rolls for the first time.

Shipment of the electrical equipment to the Detroit site will be made about mid-summer 1952. The new mill, which is part of a program now under way to add an estimated million tons of steel to production in the Detroit area by 1953, will go into production before the end of next year.

NEVADA TO GET NEW TITANIUM PLANT

▲ The first large scale and self-contained plant for titanium metal production will be constructed at Henderson, Nev., by Titanium Metals Corp. of America, a company owned jointly by National Lead Co. and Allegheny Ludlum Steel Corp. The project, which will increase world production of titanium metal eightfold, was announced today following the signing of a letter of intent by the General Services Administration, an agency of the United States Government.

Leases have been secured on major components of the $150,000,000 former Basic Magnesium, Inc. plant built by the Government during World War II at Henderson. The Colorado River Commission has allocated an annual power supply of 151,000,000 kwhr generated at nearby Hoover and Davis dams. Terms of the contract with the Government call for an initial production of 3600 tons of titanium metal per year, and operations are expected to reach this level by late 1952. Operations at Henderson will include the production of titanium sponge and the melting of the titanium metal into ingots. The Government has awarded Titanium Metals Corp. a certificate of necessity covering these installations, and has assured the company proper priorities for obtaining process equipment.

Exceptional physical properties of titanium metal and titanium-base alloys have brought about an urgent demand for the so-called "wonder metal" from both military and atomic energy agencies.

AWARD CONTRACT FOR FAIRLESS POWER PLANT

▲ United States Steel Co. has awarded a contract for the engineering, design, and construction of a 60,000-kw electric power station for the Fairless works of the company, now under construction near Morrisville, Pa.

In addition to the power station, the New York engineering firm will undertake the engineering and design of mains to bring blast furnace gas to the power station as a fuel and of an underground 13.8-kv electrical system. They will collaborate with the equipment manufacturer in the engineering and design of four electric substations and a system of supervisory and telemetering controls.

Fresh and cleaned water for the power station boilers and water returned to the Delaware River from the station will flow at different levels through a concrete duct 17 ft high and 14½ ft wide with walls 18 in. thick, extending approximately 3000 ft from a river-side pump house.

The main power house will be 108 ft high and cover an area 233× 224 ft, with a stack 146 ft above yard level. The outside walls of the power station will be of corrugated galvanized sheets, in keeping with other buildings of Fairless works. Main equipment of the power station will comprise two 30,000-kw turbo-generators; three 110,000 cfm turbo-blowers; and three 300,000 lb per hr, 885-lb pressure, steam generators.

USE THE ENGINEERING MART

INDEX TO ADVERTISERS

SEPTEMBER, 1951

A

Aetna-Standard Engineering Co., The 1
Air Reduction Sales Co. 55
Ajax Flexible Coupling Co. 22
Alliance Machine Co. 46
American Chemical Paint Co. 214
Ampco Metals, Inc. 213
Amsler Morton Corp. 65
Askania Regulator Co. 235

B

Bailey Meter Co. 239
Bantam Bearings Division of The Torrington Co. 264
Bedford Foundry and Machine Co. 240
Birdsboro Steel Foundry and Machine Co. 32
Bliss Co., E. W. 271
Bloom Engineering Co. 222
Bonnot Co., The 224
Brooks Oil Co. 49
Browning and Co., Inc., Victor R. 242
Bussmann Manufacturing Co. 196, 197

C

Chemsteel Construction Co., Inc. 253
Cities Service Oil Co. 43
Clark Controller Co. 258
Cleveland Crane and Engineering Co. 68
Continental Foundry and Machine Co. 9, 10
Crane Co. 33
Cutler-Hammer, Inc. ..... Cover 2

D

De Laval Separator Co. 215
De Laval Steam Turbine Co. 251
Delta-Star Electric Co. 241
Documentation & Licenses, Paris, France 72
Drever Co. 260

E

Eichleay Corp. 266
Electric Controller and Manufacturing Co. 11, 217
Electric Products Co., The 240
Electric Service Manufacturing Co. 53
Elliott Co. 60, 61

F

Falcon Bronze Co. 242
Farrel-Birmingham Co., Inc. 47
Farval Corp. ..... Cover 3
Flinn & Dreffein Engineering Co. 72
Flower Manufacturing Co., D. B. 263
Foote Brothers Gear & Machine Corp. 52
Foxboro Co. 70
Freyn Engineering Dept., Koppers Co., Inc. 34
Furnace Engineers, Inc. 209

G

General Electric Co. ..... Cover 4, 30, 31
General Refractories Co. 4, 5
Gould-National Batteries, Inc. 18
Graphite Metallizing Corp. 273
Gulf Oil Corp. 41

H

Hagan Corp. 247, 250
Hagan Co., George J. 259
Hallden Machine Co., The 72
Harbison-Walker Refractories Co. 16, 17
Harnischfeger Corp. 27, 227
Hays Corp., The 226
Heil Process Equipment Corp. 244
Heppenstall Co. 199
Homestead Valve Manufacturing Co., Inc. 243
Hunt and Son, Inc., C. B. 274, 275
Hyde Park Foundry and Machine Co. 244
Hydropress, Inc. 221

I

Ideal Industries, Inc. 272
International Graphite and Electrode Corp. 265

J

Johns-Manville Corp. 54

K

Koppers Co., Inc. 38, 39
Kuljian Corp., The 71

L

Leeds and Northrup Co. 50
Leslie Co. 246
Lewis Foundry and Machine Div., Blaw-Knox Co. 23
Linde Air Products Co., A Division of Union Carbide and Carbon Corp. 62
Link-Belt Co. 14, 15
Lintern Corp. 234

M

Mackintosh-Hemphill Co. 232
Magor Car Corp. 246
Manning, Maxwell and Moore, Inc., Shaw-Box Crane and Hoist Division 254
Marvel Engineering Co. 257
Mathews Conveyer Co. 216
McDowell Co., Inc. 205
McKee and Co., Arthur G. 248
Medart Co., The 212
Mesta Machine Co. 2, 3
John Miles & Partner (London, Ltd.) 72
Minneapolis-Honeywell Regulator Co. (Industrial Div.) 6, 7
Morgan Construction Co. 63
Morgan Engineering Co. 268
Morganite, Inc. 236
Murray Manufacturing Co., D. J. 246

N

Nagle Pumps, Inc. 275
National Bearing Division, American Brake Shoe Co. 8
National Carbon Co., A Division of Union Carbide and Carbon Corp. 230, 252
National Electric Coil Co. 36
Northern Engineering Works 35

O

Oakite Products, Inc. 233
Okonite Co., The 249

P

Pacific Pumps, Inc. 59
Palmer Bee Co. 229
Pennsylvania Transformer Co. 237
Pittsburgh Lectromelt Furnace Corp. 74
Pittsburgh Rolls Division, Blaw-Knox Co. 223
Pollock Co., Wm. B. 28
Poole Foundry and Machine Co. 58
Post-Glover Electric Co. 37
Pyle-National Co. 67

R

Railway and Industrial Engineering Co. 219
Rockbestos Products Corp. 267
Rust Furnace Co. 195
Rust-Oleum Corp. 66
Ryerson and Son, Inc., Joseph T. 211

S

Salem-Brosius, Inc. 206
Shell Oil Co. 44, 45
Shenango-Penn Mold Co., Centrifugal Castings Division 210
Shenango-Penn Mold Co., Mold Division 208
SKF Industries, Inc. 56
Speer Carbon Co. 40
Spraying Systems Co. 274
Stearns Magnetic Manufacturing Co. 228
Surface Combustion Corp. 12, 13
Sutton Engineering Co. 26

T

Taylor Sons Co., Chas. 20
Taylor Chain Co., S. G. 218
Tide Water Associated Oil Co. 255
Timken Roller Bearing Co., The ..... Cover 1, 201
Tool Steel Gear and Pinion Co. 57
Trabon Engineering Corp. 202
Treadwell Construction Co. 64
Truflo Fan Co. 270

U

Union Carbide and Carbon Corp., Linde Air Products Co. 62
Union Carbide and Carbon Corp., National Carbon Co. 230, 252
Union Steel Castings Div., Blaw-Knox Co. 245
United Engineering and Foundry Co. 19

V

Valley Mould and Iron Corp. 256
Van Pelt Electric Co. 282
Vaughn Machinery Co. 29

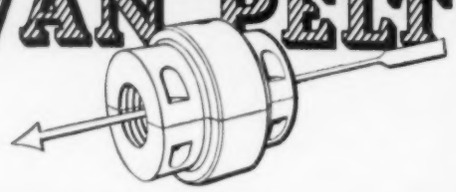
W

Wagner Electric Corp. 21
Wapakoneta Machine Co. 220
Wean Engineering Co., Inc., The 72
Wean Engineering Co. of Canada, Limited, The 72
Wean Equipment Corp. 72
Wellman Engineering Co., The 261
Westinghouse Electric Corp. 24, 25

Y

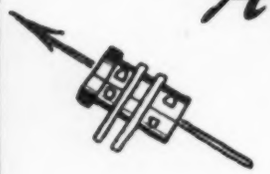
Yale & Towne Manufacturing Co. 51
Yoder Co., The 225
York Engineering & Construction Co. 238
Youngstown Alloy Casting Corp. 262
Youngstown Foundry and Machine Co. 248
Youngstown Welding and Engineering Co. 42

VAN PELT



+ MOTOR + CHANGEOVERS

Averaged Service Reports Show



That maintaining an old sleeve bearing motor on a tough job is costing you at least this **minimum** every year. (Proportions derived from over 1000 motor service reports).

Ed the Electrician Says . . .

"I'd rather operate and maintain my motors at these lower costs, wouldn't you?"

To make the necessary frame alterations and buy the Van Pelt parts will cost you about this portion. When complete, sleeve bearing armatures still fit the old frame.

To operate the same motor for years to come will now cost you this — proof that Van Pelt Motor Changeovers will save you money.

VAN PELT ELECTRIC CO.

105 FAHNESTOCK ROAD • PITTSBURGH 15, PA.

Protected by Farval

. . . not a bearing lost in 20 years

EVER since it was built in 1931, Farval has provided dependable lubrication for Cleveland's oldest continuous hot-strip mill.

There has never been a breakdown due to faulty lubrication, never a work stoppage or holdup on account of hot bearings or to lubricate hard-to-reach points.

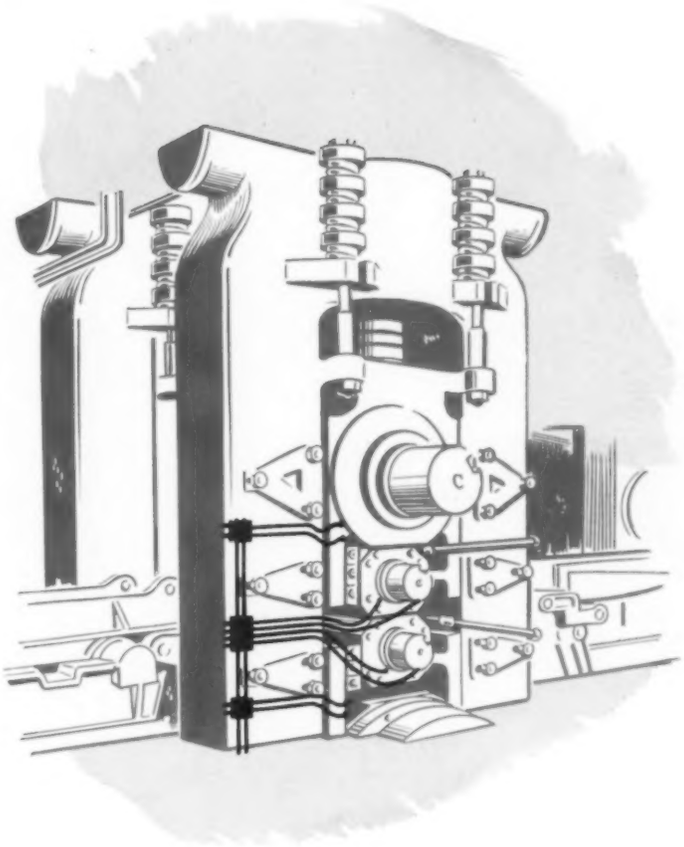
This Farval installation serves more than 6,000 points on work roll bearings, screwdowns, chutes and loopers, cooling beds, tables, coilers, flying shears, levellers and miscellaneous processing lines. Each time the mill was expanded, further Farval protection was provided.

In steel mills, metal working plants and manufacturing establishments of all kinds, both at home and abroad, Farval Centralized Lubrication is protecting millions of industrial bearings.

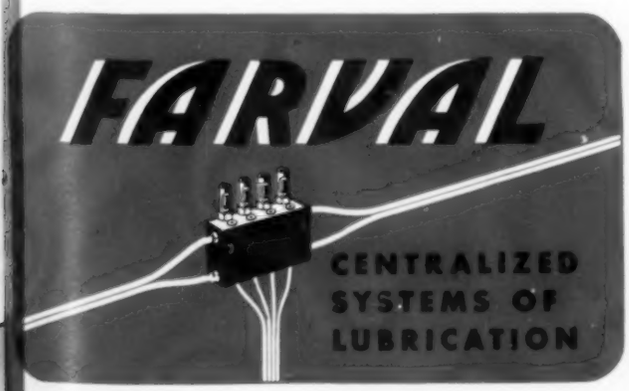
Farval is the original Dualine system of centralized lubrication that has proven itself through more than 20 years of service. The Farval valve has only 2 moving parts—is simple, sure and foolproof, without springs, ball-checks or pinhole ports to cause trouble. Through its full hydraulic operation, Farval unfailingly delivers grease or oil to each bearing—as much as you want, exactly measured—as often as desired. Indicators at every bearing show that each valve has functioned.

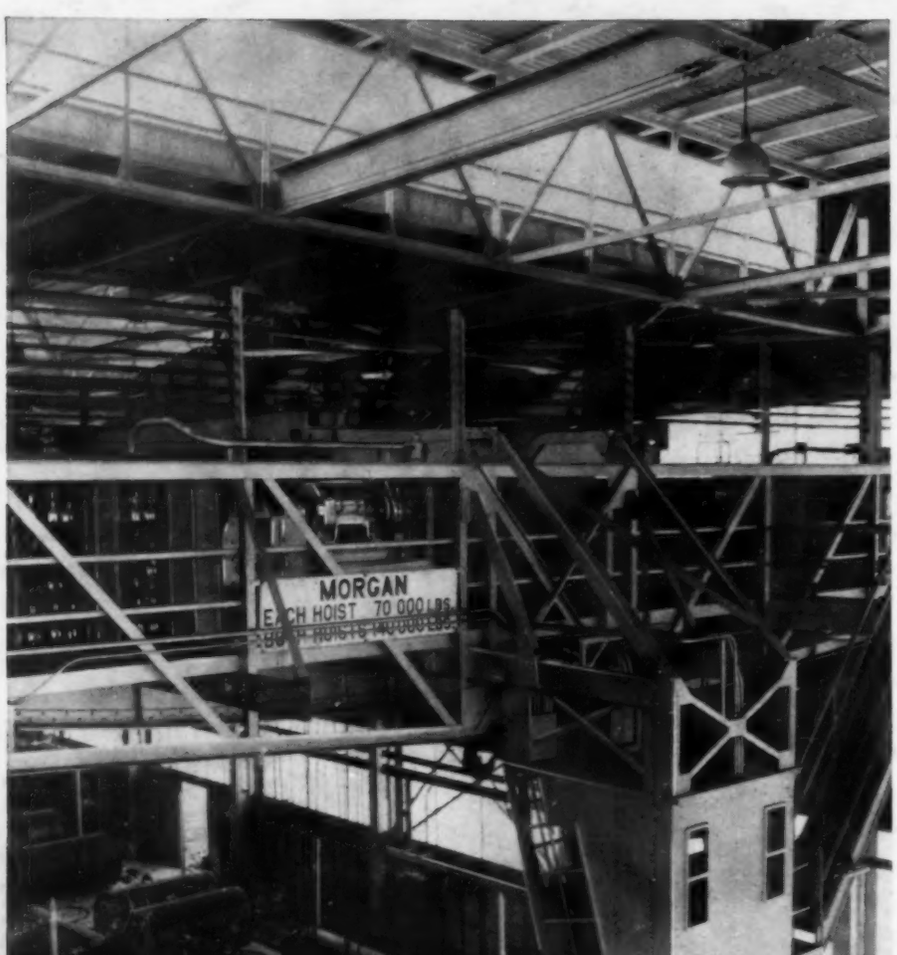
For a full description, write for Bulletin No. 25. The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Co., Industrial Worm Gearing. In Canada: Peacock Brothers, Ltd.

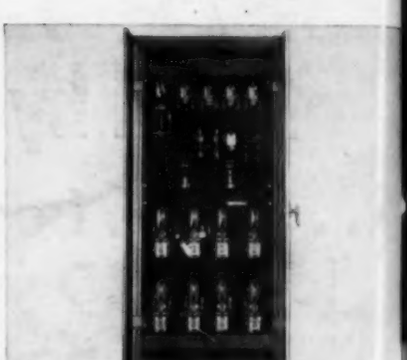


FARVAL—*Studies in Centralized Lubrication* No. 113





This 70-ton crane in a large steel mill—with a double hoist each rated 35 tons—is one of seven, all equipped with G-E crane drives, including Type MD-600 motors and hoist, bridge and trolley controls.



G-E crane control provides superior lowering performance for any hook load.

G-E MD-600 crane motors offer improved ventilation and maintenance ease.

G-E fast acting magnetic brake permits easy adjustment, requires less maintenance.

New control protects against overloads!

G-E hoist control panel solves tough motor maintenance problem; leads to choice of seven new G-E crane drives in large steel plant.

CO-ORDINATED

D-C CRANE DRIVES

Here's the kind of success story that's making General Electric crane control a heavy steel-mill favorite. In the box annealing building at this large mill, a 10-ton auxiliary hook on a mill crane was handling stacks of steel sheets to be put into annealing furnaces. Because the crane was frequently overloaded, two to four motor breakdowns a year had occurred over an eight-year period.

A G-E hoist control panel was installed in place of the previous magnetic control, providing safe and stable full-speed lowering operation for heavy overloads. Result: Motor breakdowns were cut to zero during the next 20-month period before the crane was retired from this severe duty. Furthermore, motor maintenance had been reduced by the lower commutating peaks and improved automatic deceleration. So impressed were the mill operators by this outstanding performance that they selected G-E crane control, plus G-E MD-600 crane motors, for seven new crane installations (one shown above).

Is *yours* a tough crane drive problem? General Electric—with over 40 years of experience in working with crane builders—can help you solve it. Ask your G-E steel-mill specialist about it; meanwhile send for Bulletin GEA-5408 on G-E d-c crane drives. *General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

659-81